MINING engineering

SEPTEMBER 1955

MINING engineering

VOL. 7 NO. 9 SEPTEMBER 1955

COVER

By Herb McClure . . . Making rock grind itself has been an aim of mill designers for many years. Culmination of these efforts has come with the Aerofall mill now in use on two continents. For the story of this mill turn to page 842.

The AIME also publishes **Journal of Metals** and **Journal of Petroleum Technology.**

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PERSONNEL

THE following employment items are made available to AIME members on a non-profit basis by the Engineering Societies Personnel Service Inc., operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E. Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

MEN AVAILABLE

Mining Engineer, 27, married, B.S. Korean veteran. Three years experience gypsum exploration and development U.S. and abroad, including supervision diamond drilling and testing, reports on geology and evaluation of deposits, and geological mapping. Desires position with good prospects in any phase of exploration, development, and production. Employed. Available 30 days notice. M-238.

Petrologist-Mineralogist—Economic Geologist, Ph.D., 34, at present in mining exploration. Research-minded, 5 years teaching and 4 years industrial experience. Would like industrial or research position with progressive company or state geological survey or academic position with research facilities. M-236.

Mining Engineer, 37, married, no children, B.S., mining engineering. Fourteen years varied mining experience exploration, engineering, designing, production and administration, underground and placer mines, U.S. and South America. Speaks Spanish and Portuguese. Desires responsible position with mining company, domestic or foreign. Now employed; available 30 days. M-237-SF-727.

Exploration Manager of small mining company operating in East Africa; American; M.S. geology, 10 years experience oil and mineral exploration in Africa, U.S., and South America. Desires exploration assignment, Africa or Near East. M235.

POSITIONS OPEN

Vice President-General Manager to take charge of the exploitation of exceptionally rich mineral deposits in Central America. Operation employs about 370 technicians, laborers in mining, purifying, and shipping. Salary open; plus bonus and stock option plan. Income tax low. F1925.

Plant and Sales Managing Engineer, for small nonmetallic crushing, drying, and bagging plant treating bentonite. Salary, $9600 a year. Location, Wyoming. W1944.

Mining Engineers, young graduate engineers, to work into operations with large open pit contractor in Arizona and New Mexico. Starting salary, $6000 year. S328.

Supervisor, Mining Engineer, up to 45. Must have had at least 4 years experience as mining engineer, preferably in both metallic and nonmetallic phases, and must know safe and efficient operations. Will participate in the development of company's wide engineering programs, policies, methods, and procedures. Company manufactures minerals and chemicals. Salary, $7500 to $12,000. Employer may negotiate placement fee. Considerable traveling. Headquarters, Chicago. C3309.

Mineral Laboratory Testing Assistant, B.S. mining or metallurgy, young, preferably with both testing and operating experience (testing not essential). Will test minerals, rocks, sand, and gravel to determine methods and equipment to treat the

Graduate Research Fellowship in Chemistry. $2,400 plus tuition, 12 months. Write Dr. Wilhelm Eitel, Director, Institute of Silicate Research, University of Toledo, Toledo 6, Ohio.

TEACHING POSITION: at the level of Instructor or Assistant Professor in Geological Engineering Curriculum. Should be capable of teaching general geology, stratigraphy, and geomorphology. Opportunity for research. Location North Carolina.
Box 10-H AIME
29 West 39th St. New York

MINING ENGINEER: To keep abreast mining activities in Nevada, examine new mineral discoveries, give technical assistance to prospectors and small mining operations. Prefer man with 5 or more years' experience in industry. Salary $4,800 to $5,800. U. S. citizen or first papers. Write: Vernon E. Scheid, Director, Nevada Bureau of Mines, University of Nevada, Reno, Nevada.

ENGINEER FOR MINERAL TESTING LABORATORY

Large S.F. manufacturer of metallurgical and process equipment. Seeks field trained graduate for mineral testing laboratory. Testing experience desired. Work involves variety of metallic and non-metallic minerals utilizing numerous concentration methods. Opportunity to work into sales. Extra benefits and retirement plan. Our employees know of this ad. Give full details of experience, employment record, special training, personal history, photo, references, salary desired.
Box 12-J AIME
29 West 39th St. New York, N. Y.

materials for mining machinery company. Opportunity to work into sales. Salary, $3600 to $4800 year. Location, San Francisco. S326.

Instructor or Assistant Professor of Mining Engineering, 25 to 40, M.S. preferred. Prefer about 4 years field experience accompanied by teaching experience, if possible, and must have knowledge of mining principles and practices. Will teach courses in mining engineering dept., assignments depending on individual's background and preference. Salary, $3800 to $5200 per academic year. Location, South Dakota. C3419.

Geologist, up to 40, recent graduate or better with training in minerals. Must know economics and marketing. Will handle geological problems within research div. and/or studies on economics and markets and related fields for manufacturer of fertilizer. Salary, $4200 to $7200 year. Twenty-five pct traveling. Location, N.W. Chicago suburb. Car helpful. C3408.

Geologist, Mineralogist or Mining Engineer, up to 40. Must have had at least 2 years experience in research and assay work on minerals, clays, ceramics or allied lines. Will do research work on minerals, clays, ceramics, ores, etc. for refinery of petroleum. Salary, $5000 to $8000 year. Location, Calumet District of Chicago. C3388.

Maintenance Superintendent to take over entire maintenance program of stone quarrying and crushing operation. Must be familiar with diesel engines, tractors, shovels, diesel trucks, crushing and screening equipment, etc. Salary open. Location, Mideast. W1914.

Mineral Dressing Engineers, graduate metallurgical engineers, with minimum of 5 years experience in mineral dressing or process metallurgy. Company operates an AEC laboratory. Salary commensurate with experience and training. Location, New England. W1924.

Field Engineer, metallurgy, 25 to 35, for smelter of precious metals. Must have at least 2 years experience in heat treating, brazing or welding. Knowledge of electronics helpful. Salary, $4200 to $6000 a year. Employer will pay placement fee. Location, Chicago. C3407.

Supervisor Minerals Beneficiation, metallurgical or mining engineer, up to 45. Must have had at least 4 years experience in mineral beneficiation work, and knowledge of metallic and nonmetallic mining. Will develop and direct minerals beneficiation program and formulate policies regarding minerals and encourage use of these services by operating divisions. Salary, $7500 to $12,000 a year. Employer may negotiate placement fee. Considerable traveling. Location, Chicago. C3310.

Coal Mining Engineer, graduate, with or without coal mining experience, to learn coal mining engineering. Salary open. West. W1818.


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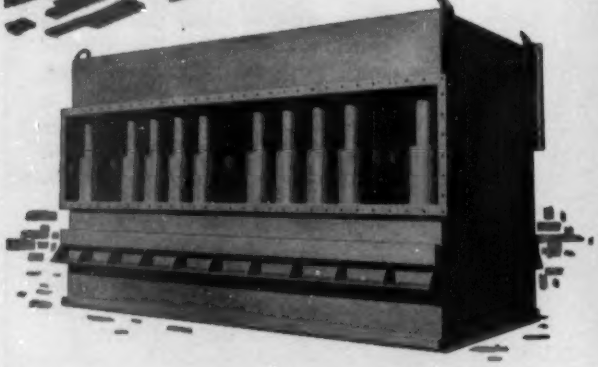

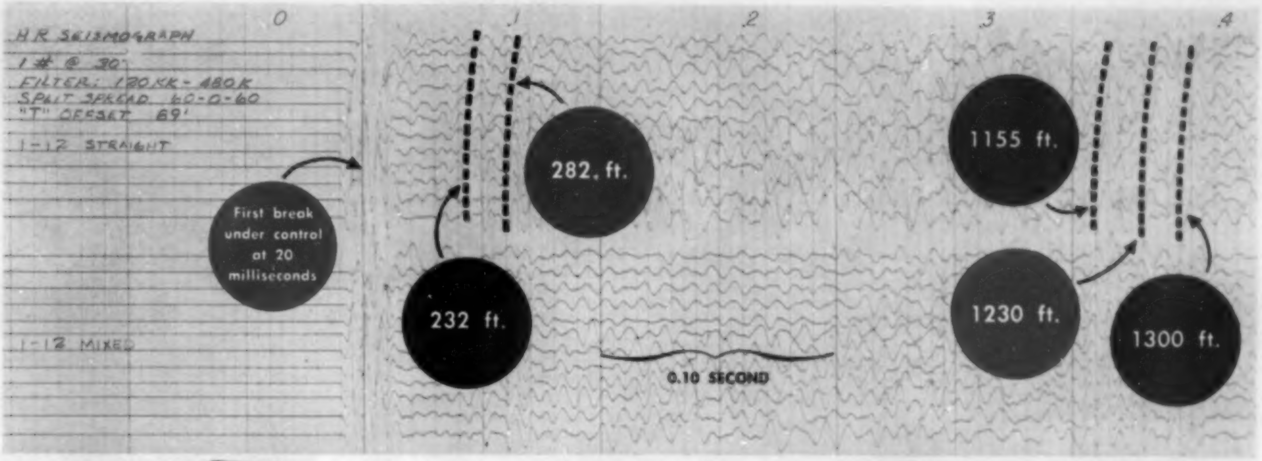

High Resolution

here's a new record for near-surface seismic data

use the HTL portable HR seismic system to determine:

- thickness of gravels and other unconsolidated materials;
- depth and extent of buried channels;
- location and delineation of shallow mineral beds or seams, dikes, pinchouts, lenses and similar features.

If you're plagued with the problem of obtaining accurate near-surface seismic data, look carefully at the record illustrated here. With first breaks under control in 20 milliseconds, a reliable reflection was obtained at a depth of 232 feet. This record is typical of the results obtained by the new Houston Technical Laboratories High Resolution Seismic System. A major development in geophysical prospecting, the HTL portable HR System now makes possible reliable reflection surveys over a depth range of 100-2500 feet. It is especially designed for use in petroleum exploration, mining, ground water location, and civil engineering where shallow seismic information is vital.

WRITE for Technical Bulletin No. S-303 for additional information about how you can now make shallow seismic surveys.

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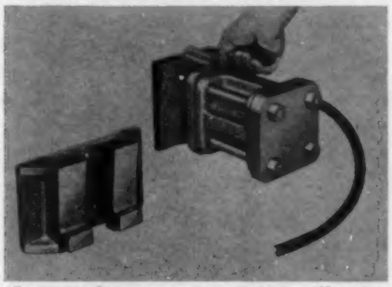
Vibration Plus

Cleveland Vibrator Co. has developed the type LSRRH vibrator for heavy duty use on portable bins, trucks, concrete forms, and other



places where a permanent vibrator is not called for. Frequency is 7000 to 8000 vibrations per min. **Circle No. 1**

Faster Quenching

A quenching oil for extremely fast cooling rates offered by *Shell Oil Co.* has made it possible to quench low carbon or low alloy steels in oil where formerly water was necessary. Voluta Oil 23 also features high oxidation stability and low smoke and flame. **Circle No. 2**

Two Big Scrapers

Euclid Div. of General Motors is in production on two overhung engine type 18-yd scrapers. Both have Allison Torqmatic drive with tor-

que converters and semiautomatic transmission. Model S-18 has a 300-hp diesel while Twin-Power model TS-18 has two 194-hp engines, one for tractor wheels and the other for the rear wheels. Full 90° steer means 180° turns in 35 ft or less. **Circle No. 3**

Tough Cord

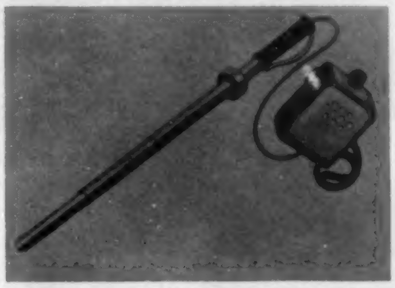
Laytex Royal Master electrical cord for portable machinery is claimed to have three times the service life of present high quality cords. Developed by *U. S. Rubber Co.*, the cord is result of more than 15,000 tests. **Circle No. 4**

Compact Elevator

Meltevator, manufactured by *Nolan Corp.*, is an automatic elevating and dumping mechanism adapted to top loading of bins, furnaces, or other receptacles. Capacity is 800 lb and compact 30x30-in. installation has standard 4-ft lift. Special units have greater lift. **Circle No. 5**

Walking Stick Counter

Universal Atomics Corp. has available a walking stick Geiger counter that includes a transistorized audio amplifier. Rugged for field use, the



UAC 402 weighs 3 lb, is 40 in. long by 2 in. diam, and operates more than 1000 hr on two 15¢ flashlight batteries. **Circle No. 6**

Light Coal Drill

A 25-lb hydraulic coal drill introduced by *Jeffrey Mfg. Co.* is claimed lighter, faster, and more efficient be-

cause of its aluminum housing and axial piston-type hydraulic motor. Up to fourteen 1⅝-in. by 9-ft holes have been drilled by the A9A in 5 min. **Circle No. 7**

Bigger Payloader

Third and largest of the four-wheel tractor shovels in the new Payloader line was unveiled by the *Frank G. Hough Co.* Designated model HO, the 2-yd unit has similar appearance to earlier 1 and 1½-yd HU and HH models. Features are

"pry-out" bucket action, 40° breakout at ground level, and high standards of safety and stability. Special feature of the HO Payloader is "complete" power shift transmission—without clutch pedal and shiftable in all ranges without stopping or slowing down. Underslung boom-arm gives driver more safety and visability. Gasoline or diesel power is optional. **Circle No. 8**

Portable Pyrometer

Employing new method for surface temperature measurement, Land surface pyrometer spot checks surface temperature to 2400°F with accuracy of 0.5 pct. Heated materials in cool surroundings are no problem to instrument, according to producers, the Fielden Instrument Div. of *Robertshaw-Fulton Controls Co.* **Circle No. 9**

Drill Scout

Specialized mobile drill rig developed by *Gustafson Mfg. Co.* has capacity to handle 200-ft holes and offers one-man operation. Price tag is about $1250 for the 1000-lb ma-

chine, which is powered with a 6 or 9-hp gasoline engine. Two water pumps, a hydraulic pump, and variable speed kelly bar with 6-ft travel are listed highlights. **Circle No. 10**

Dust Collector

The Hydro-Filter, wet-type dust collector which uses glass spheres as filtering media, was introduced by *National Dust Collector Corp.* Advantages and outstanding features cited are: self-cleaning on a 24-hr basis, low maintenance, low water requirement, and high efficiency. **Circle No. 11**

Rubber-tired Dozer

First rubber-tired dozer powered by a turbocharged diesel has been introduced by *Clark Eqpt. Co.* This

model 180 Michigan Turbo-Dozer has 185-hp, 2¾-yd capacity, with up to 27 mph road speed. **Circle No. 12**

Flocculating Agent

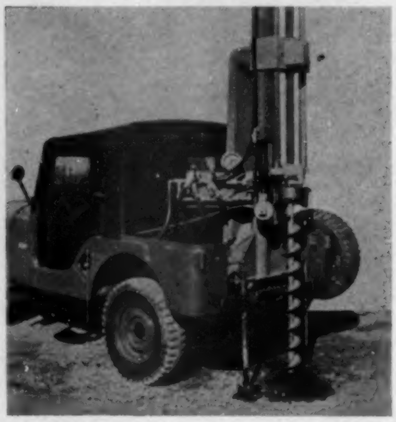
Development of a synthetic resin flocculating agent for clarification, sedimentation, or filtration operations was announced by *B. F. Goodrich Chemical Co.* Agent, called Good-rite K-720, improves the degree and rate of sedimentation and at same time improves filtration rates. As little as 0.01 lb of K-720 per ton of dispersed solids is reported sufficient in slime treatment. Resin is also available as 20 pct water solution. **Circle No. 13**

New Twist in Wrenches

Wrenches are usually wrenches—no glamor. This one however, called the *Stilsomatic* Red Snapper, has some special claims: tubular steel construction, automatic adjusting rocking fulcrum, spring-loaded hook jaw, and light weight. **Circle No. 14**

Earth Drill

New earth drill, mounted on either two or four-wheel drive vehicle was designed by Toledo Testing Laboratories to meet need for speedy and accurate data on soil structures and rock formations. *Continental Eqpt. Sales Inc.* is distributing the Toledo drill. Rated to more than 100 ft in



earth, and more than 300 ft with diamond bits, drill power supply is from vehicle take-off or from separate engine. **Circle No. 15**

Better Chain

"Weld is stronger than link itself," claims *American Chain & Cable* for its x-weld heavy duty sling chain. Increased weld area is secret of higher strength. Manufactured in 1/4 to 3/4-in. sizes; load limits are from 3250 to 23,000 lb. **Circle No. 16**

Deep Hole Counter

The DG-9 deep hole Geiger counter available from the *Radiac Co. Inc.* was specially engineered for reliability of performance and stability in subsurface uranium exploration. The DG-9 can be used to probe to 1000-ft, and the circuit gets 900 v from standard batteries. **Circle No. 17**

Shuttle Car Cable

A new shuttle car cable with greatly increased life has been announced by *Anaconda Wire & Cable Co.* Securityflex cable "has physical toughness on the inside as well as on the outside," with heat resistant

neoprene insulating compound to increase resistance to puncture, crushing, and cutting. The cable jacket is also neoprene. Greater protection against short circuits is provided by a patented nylon breaker strip. **Circle No. 18**

Free Literature

(21) DIAMOND DRILL BITS: *Diamond Tool Research Co.*, a new supplier of diamond drill bits, has a catalog showing how DTR gives more value per dollar, skillful selection and mounting of stones, and the right matrix for the job.

(22) UP-TO-DATE ENGINEERING: New $3 million Kerr-McGee plant constructed by *Western Knapp Eng. Co.* incorporates latest methods for extraction of uranium concentrates. WKE's bulletin G1-B4 contains complete information on this progressive engineering firm.

(23) GAMMA SURVEY: Descriptive literature is available from *Universal Atomics Corp.* on the SC-12, first scientifically engineered completely transitorized gamma survey instrument. Featuring stability because of exterior compensating controls to offset electrical drift, unit has a series of 5x8-in. crystals to fit utmost sensitivity requirements.

(24) DRILL: Bulletin RD30 from *Cleveland Rock Drill Div.* describes H10AL drills with AL92 telescopic air legs for slusher drift development. These drill combinations not only drill the round but also can be used to roof bolt.

(25) DUST COLLECTION: Want worry-free continuous dust and fume collection at full rated capacity? *Northern Blower Co.'s* Norblo has automatic bag cleaning, no down time, and low, easy maintenance.

(26) ORIENTED DIAMOND BITS: After extensive tests, *Sprague & Henwood* has decided random setting is obsolete. Diamond drills cut faster, last longer with their hardest edge or "vector" toward the work. Bulletin 320 illustrates all S&H types and gives complete working data.

(27) TRACTOR: The *Caterpillar* D9 is said to be the world's largest and most powerful tractor. Form 31555 presents pictures of the 56,200-lb tractor, 286-hp engine, and exhaust-driven turbocharger.

(28) DRILLING: Small hole drilling, air legs, and nonrifling Rok-Bits are three ways to "lowest-cost drilling." Shown in *Brunner & Lay's* bulletin are tools for large as well as small hole drilling.

(29) VIBRATING SCREEN: Utilizing the principle of "modified resonance," the *Hewitt-Robins* hi-G screen answers the demand for larger vibrating screens with lower power and space requirements. Available in sizes up to 6x28 ft, hi-G screens develop a controlled, extremely sharp vibrating action and require not more than 15-hp drive.

(30) GEIGERS & SCINTILLATORS: The amusing illustrations alone make the pocket-size booklet from *Precision Radiation Instruments Inc.* worth having. In question and answer form it quickly and concisely

covers: claim staking, Government bonuses, assaying of radioactive ores, aerial and ground surveys for uranium, ores, and gas fields, effect of weather on radiation, use of various types of instruments, and many other topics.

(31) ROCK DUST DISTRIBUTOR: *Mine Safety Appliances Co.'s* Bantam 400 discharges rock dust through 400 ft of 2-in. hose at an average 30 lb per min. Only 15 in. high without the hopper, it can be carried on any conveyor belt, or in a shuttle or mine car in the thinnest seams of coal. The Bantam is available with a special nozzle to discharge wet rock slurry for fire fighting purposes and is approved by the USBM.

(32) COMPRESSOR: Bulletin 16B8244 from *Allis-Chalmers* covers two-stage sliding vane-type compressors for shop air, gas handling, drilling, and many other applications. Compressors, designed for low maintenance and constant efficiency, are built in various sizes to deliver air at pressures from 60 to 125 lb.

(33) ANTIFRICTION ALLOY: *Graphitized Alloys Corp.* has a brochure listing the ten outstanding advantages of GRAC, a graphite containing lead-base babbitt metal. GRAC, a substitute for any of the high tin-base babbitt metals, gives assurance against failure due to temporary shortage or lack of lubrication.

(34) LOW-COST PUMPING: By designing and manufacturing pumps that deliver cost-saving performance on every application, *A. R. Wilfley & Sons Inc.* keeps pace with mineral production throughout the world. Complete details are available on efficient, economical pumps.

(35) DIAMOND BITS: Five EX Standard Drillco diamond-impregnated bits drilled a total of 2647 ft at an average of 32¢ per ft. Catalog from *Diamond Products Inc.* contains further proof of the economical drilling possible with these bits.

(36) REDUCTION CRUSHER: Why did 836 profit-wise ore producers decide to buy the same crusher? *Traylor Eng. & Mfg. Co.'s* bulletin 7112 on the Traylor TY tells full story.

(37) ROCK DRILL OILERS: Pneumatic equipment must be adequately lubricated throughout the shift to maintain "like new" performance. Oilers guaranteed to deliver this service are illustrated in *Howard Drullard Co.'s* catalog.

MAIL THIS CARD

for more information on items described in Manufacturers News and for bulletins and catalogs listed in the Free Literature section.

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

Not good after Dec. 15, 1955—if mailed in U. S. or Canada

Please send me { More Information ☐ / Price Data ☐ / Free Literature ☐ } on items circled.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
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61	62	63	Students should write direct to manufacturer.						

Name________________________ Title____________

Company____________________________________

Street______________________________________

City and Zone_______________________ State__________

(38) BALL BEARINGS: The *Dodge Mfg. Corp.* 52-page bulletin on Dodge SC ball and Dodge-Timken roller bearings introduces the SCM ball bearing pillow block for medium duty service. Metal-backed synthetic seals are mechanically anchored and cannot be blown under grease gun pressure.

(39) MINING EXPERIENCE PLUS: Available are full details on the many services offered by *Boyles Bros. Drilling Co.* This organization has had more than 50 years experience in exploration and development, diamond core drilling, grouting, rock breaking, mining, quarrying, and tunnel driving.

(40) FLOTATION: Bulletin F12-B8 from *Denver Eqpt. Co.* tells how Denver Sub-A unit flotation cell recovers coarse mineral, lowers reagent costs, reduces losses in plant tailings, increases capacity of circuit, and lowers power consumption. Flowsheets show applications.

(41) LUBRICATION: The development of molybdenum disulphide lubricants for extreme bearing pressures or excessive temperatures is told in brochure from *Alpha Molykote Corp.* Shown is some of the equipment used in German laboratory as well as Stamford, Conn., research facilities.

(42) FOR U_3O_8: *Stratex Instrument Co.* has full details on the DR-299 Nucliometer. To be used as probe Geiger, for radiometric assays, or for low level radiation, the DR-299 has four time constants, 6 ranges from 20.0 to 0.01 MR/HR for surface or carborne work, and 18 powerful Geiger tubes that defy temperature extremes.

(43) MILLING: Marcy mill catalog 101-A from *Mine & Smelter Supply Co.* includes complete data on: latest metallurgical and mechanical developments in ball, rod, tube, and pebble mills; how to select a mill; the power and capacity of grinding mills; and grinding media.

(44) STRADDLE DUMP CARRIER: Brochure from *Clark Eqpt. Co.* shows the hydraulically operated dumping device for use with the 20,000-lb capacity Ross straddle carrier. Boxlike containers for gravel, coal, sand, and other bulk materials can be picked up, transported, and dumped in a one-man operation.

(45) MINING MACHINE BITS: Carmet Div. of *Allegheny Ludlum Steel Corp.* has a leaflet on "G" and "H" series of mining machine bits. Experience on continuous miners is said to have demonstrated lower tool costs and reduced down time when these bits were used.

(46) VERTICAL MOTOR: The 12-page bulletin GEA-6280 from *General Electric* features vertical Tri-Clad motor. New GE motor is of the shielded, dripproof, hollow-shaft, high-thrust type ranging from 7½ to 500 hp. Reduced maintenance costs and simplified lubrication are emphasized.

(47) STEAM GENERATORS: To reduce steam costs for industrial plants, *Foster Wheeler Corp.* has developed the "SC" economy series of standard steam generators. Generators are offered in nine sizes with capacities 50,000 to 150,000 lb per hr.

(48) METALLIZING: Folder on metallizing benefits from *Metalweld Inc.* tells of new spraying technique: damaged surfaces can often be sprayed and finished in place in a plant.

(49) MINING, MATERIAL HANDLING, PROCESSING: Booklet 888 from *Jeffrey Mfg. Co.* is a quick and concise picture of the Jeffrey story and line of products. Keep it handy to send for individual catalogs on specific items.

(50) STORAGE EQUIPMENT: *Frick-Gallagher Mfg. Co.'s* 16-page catalog shows more than 24 new ideas in space and timesaving equipment. Photographs show racks, bins, shelves, and pallet frames for more efficient storage.

(51) TRACTOR: There's "more time working, less time servicing" with the HD-9 tractor described in *Allis-Chalmers'* 29-page bulletin. Other features include: convenient controls—nothing "tricky" to learn, ground-hugging traction, heavy duty diesel engine power, and matched equipment.

(52) FLOTATION: *Western Machinery Co.'s* equipment saves on flotation reagents and conserves floor space as well. Using the Fagergren rotor for efficient energy dispersion, Wemco's high intensity conditioner intermixes pulp and reagents in record time. Square shape cuts floor space requirements to a minimum.

(53) pH METER: *Photovolt Corp.'s* pH meter model 110 has large size indicating meter of 7-in. scale length that covers the entire pH range from 0 to 14 without switching and without reversal of pointer travel. Features include simple operation, easy maintenance, shielding hood, and swing-arm adapter.

(54) AIR STARTING MOTORS: *Ingersoll-Rand's* new air starting motor, the size 5BM, is designed for gasoline engines with from 750 to 1750 cu in. displacement and for diesel engines from 300 to 700 cu in. displacement. Unaffected by climatic conditions, compact motor eliminates the necessity of generators, banks of storage batteries, and costs of battery maintenance and replacement.

(55) BRAKES & CLUTCHES: *Stearns Magnetic Inc.* has a transmission bulletin 226-D on a standard line of magnetic brakes and clutches. Included are specifications of the companion line of magnetic brakes for re-rated NEMA frame sizes.

(56) DRILLS, STEELS: *Atlas Copco* rock drills and Coromant drill steels make "an unbeatable drilling unit." Details are available on this equipment that helps beat costs on Kalgoorlie's Golden Mile in Australia and is now discovering mineral wealth in Greenland.

(57) GRAVITY METER: *Houston Technical Laboratories* has a bulletin on the world's smallest precision instrument for accurate gravity measurement. Weighing only 5⅛ lb, the sealed, self-compensating Worden meter pin-points gravity anomalies with a reading accuracy of 0.01 milligal and requires no external power source.

(58) RIFFLE GRIP CONVEYOR: Featured in *B. F. Goodrich's* data sheet on special conveyor belt constructions is the Riffle Grip conveyor. Molded cover design has a tread that forms a horizontal carrying wall when a prescribed combination of conveyor incline and concentrating idler angle is used. Wet concrete may be carried without sluicing back. In dredging operations, a load can be drained of water by idler adjustment.

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How New Akremite Method Helps Us Cut Explosive Costs 40% to 60%

... main ingredient we use in new "make-it-yourself" explosive is Spencer Commercial Grade Ammonium Nitrate

By JAMES E. MINER, *President, Colonial Coal Mining Company*

THE "Do it yourself" fad is not restricted to the basement workshop as far as the Colonial Mining Co. is concerned. Strip miners of coal now are making their own explosive for overburden shooting.

Hugh B. Lee, president, and Robert Akre, superintendent of drilling and shooting, Maumee Collieries Co., Terre Haute, Ind., have developed a new type explosive for strip and open pit mining. Called the Akremite Blasting Process, Colonial Coal Mining Co. is now using the method under license from Maumee.

Drilling and shooting conditions will vary with each mine so that no rule of thumb can be used to show shooting costs. However, Akremite is saving us 40% to 60% compared with the cheapest commercial explosive and is giving at least equivalent results when shot on a pound for pound basis.

For a specific example of the savings, take our experience at Colonial Mine. We purchased a Bucyrus-Erie 50-R drill and began using Akremite about a year ago. For an 11-month period after using this combination we enjoyed an 18-cent per ton reduction in drilling and shooting costs over a like period before its use, while our stripping ratio was reduced by one yard, from 7½ to 1 to 6½ to 1. Depreciation of the drill is included in the calculations of cost.

The main ingredient in the Akremite Method is a commercial grade ammonium nitrate. We use Spencer Commercial Grade Ammonium Nitrate. A great deal of practical research has been done by the Spencer Chemical Company in cooperation with Maumee Collieries to produce this raw material with the proper moisture content, density, screen analysis, caking quality and ability to take the correct carbonaceous coating.

(NOTE: Spencer Chemical Company will be happy to provide you with further information about the Akremite Method as discussed by Mr. Miner.)

SPENCER CHEMICAL COMPANY

610 Dwight Building • Kansas City 5, Missouri • Baltimore 6600

BOOKS

Please Order These Publications from the Publishers

Canadian Mines Handbook 1955, compiled, printed, and published by *Northern Miner Press Ltd.,* 116 Richmond St. W., Toronto 1, Canada, $3.00 Can., 352 pp., July 1955.—Up-to-date edition of the well known reference. Part I lists principal companies; Part II, supplementary list, including inactive and extinct companies; and Part III, metal mines classified and mining stock prices.

Search for Uranium in the United States, Catalog No. 1 19.3: .1030-A, Superintendent of Documents, *U. S. Government Printing Office,* Washington 25, D. C., 25¢, 64 pp., 1955.—Prepared by Vincent E. McKelvey of the USGM, this report summarizes briefly the information on the common uranium minerals; the kind of deposits in which uranium is found; the methods used in the search for uranium; the important deposits found in this country thus far; the outlook for future discoveries; and the recent literature on geology of U. S. uranium deposits.

An Annotated Bibliography on Noise, Its Measurement, Effects, and Control, *Industrial Hygiene Foundation,* Mellon Institute, 4400 Fifth Ave., Pittsburgh 13, Pa., $7.50, 364 pp., paper covered, offset printing, 1955.—A useful reference for physicians, engineers, and executives concerned with problems resulting from excessive noise. The 2336 references are arranged chronologically for greater ease in locating a particular subject and for purposes of historical background. Material is indexed by subject and author.

Report of the Committee on the Measurement of Geologic Time, 1953-1954, Publications Office, *National Academy of Sciences—National Research Council,* 2101 Constitution Ave., Washington 25, D. C., $1.75, Publication 333, 193 pp., mimeographed, 1955.

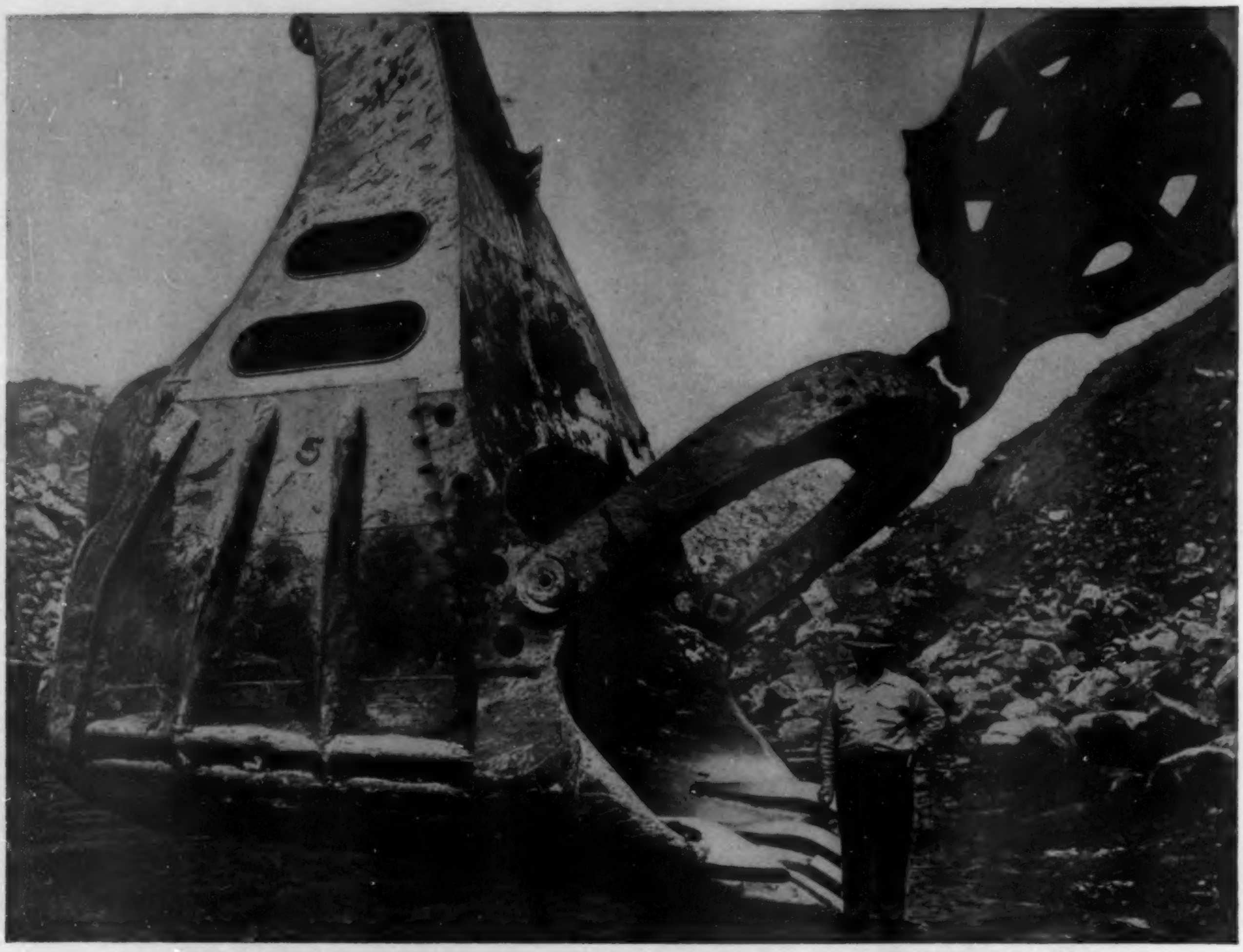
Glossary of Uranium- and Thorium-Bearing Minerals, by Judith Weiss Frondel and Michael Fleischer, Geological Survey Bulletin 1009-F, Superintendent of Documents, *U. S. Government Printing Office,* Washington 25, D. C., 20¢, 209 pp., 3rd edition, 1955.

Electronic Concentration of Low Grade Ores with the Lapointe Picker, by A. H. Bettens and C. M. Lapointe, *Dept. of Mines & Technical Surveys,* Mines Branch, Ottawa, Canada, Technical Paper No. 10, 25¢ Can., 12 pp., 1955.—Construction details of a new electronic picker unit for concentration of coarse low grade uranium ore using a scintillation detector. Typical results obtained with low grade ore from two mines in the Beaverlodge area are presented as examples of the concentration achieved with the higher sensitivity of such a detector. Comparative tests with a Geiger counter are also reported.

The Coal Industry in Europe, *Organisation for European Economic Cooperation,* 2002 P St. N.W., Washington 6, D. C., $1.00, 88 pp.—The annual report of the Coal Committee of the OEEC gives the coal balance sheet for member countries for the years 1952 and 1953 as well as estimates for 1954.

Géologie du Congo Belge, by L. Cahen, *H. Vaillant-Carmanne,* Liège, available in the U. S. from Stechert-Hafner Inc., 31 E. 10th St., New York 3, N. Y., approximately $25.50, 577 pp., 1954.—A detailed treatment in French, by geographical region and by geologic structure, of a territory of increasing importance. A useful chapter on the mineral resources of the area follows the descriptive geological information. Extensive bibliographies and detailed index.

Proceedings of Coal Conference at Missouri School of Mines and Metallurgy, edited and assembled by J. D. Forrester, *Missouri School of Mines,* Rolla, Mo., Technical Series Bulletin 85, free, 155 pp., 1954.—The conference held Dec. 3 to 4, 1953 was sponsored by the Missouri School of Mines and Metallurgy in cooperation with the Missouri Coal Operators Assn. and the Missouri Geological Survey. Illustrated.



Northern Producers Set New Coal Wage Pact

After sitting out the 1953 and 1954 rounds of wage increases, John L. Lewis and the UMW negotiated a wage agreement with the Bituminous Coal Operators' Assn. bringing miners' daily wages to $20.25, in line with auto and steel pay rates. The agreement, continuing a six-year record of no strikes, provides $1.20 per day increase for seven months and $2.00 increase for balance of year. Overtime and vacation pay benefits were included.

Union Oil Bets $5 Million on Oil Shale Test

Near Rifle, Colo., Union Oil Co. is preparing to determine economic factors in petroleum from oil shale production. The Stearns-Rogers Co. is building a 1000-tpd shale retort for the refinery. Union Oil stresses that this is not commercial-scale production—full size plant estimated to cost about $75 million.

Do-It-Yourself Reactors

The Atomic Energy Commission announced prices for materials for research reactors. Uranium enriched to 20 pct U_{235} leased for use in research reactors under agreements between U. S. and friendly nations is $25 per g of contained U_{235}. Heavy water at $28 per lb and normal uranium metal at $40 per kg are also for sale to researchers . . . AEC also declassified all technical information on currently used extraction processes for producing *unrefined uranium concentrates* (italics ours).

UC&C Integrates Atomic Energy Activities

Union Carbide Nuclear Co. has been formed to integrate Union Carbide & Carbon Corp.'s diverse interests in the field of atomic energy. UC&C has been active in this field from the beginning and the new division takes over nuclear operations of other company divisions and absorbs operations of U. S. Vanadium Co. Major expansion of the uranium mill at Uravan, Colo., was recently announced. UC&C has also taken option on a block square site for proposed office building near Grand Central Station in New York.

Copper Price at Record High

Higher prices for copper won't mean more metal; in fact, producers fear substitution if price goes too high or stays high too long. Anaconda and Phelps Dodge were first to announce 43¢ price, a record level going back to 1865. Rhodesian mines raised price earlier. American producers tried to hold the line, but Chile was reported dissatisfied at lower U. S. price. London quotation was 47¢. Users faced shortage for some time to come as U. S. strikes put final touch to situation set up by production boom and earlier strikes abroad.

U. S. Mining Scene

The New Jersey Zinc Co. has started development at Flat Gap zinc mine, Treadway, Tenn. A 2000-tpd mill is proposed . . . **Cornucopia Gold Mines** and **National Lead Co.** entered into partnership in 104 mining claims in San Juan County, Utah . . . **Southwest Potash Corp.** has undertaken a $2.5 million expansion at Carlsbad, N. M. . . . **Climax Molybdenum Co.**, active in Texas uranium, will make a strong pitch for the first uranium mill in that state. Oil companies are also active in Texas uranium field . . . **Kaiser Steel Corp.** paid $3.5 million for 529,804 acres of coal land near Raton, N. M. . . . **Permanente Cement Co.** will expand into Southern California with a $12 million, 2 million bbl plant in San Bernardino County . . . **Garfield Chemical & Mfg. Co.**, joint affiliate of Asarco and Kennecott, is planning additional sulphuric acid capacity at Garfield, Utah.

70 NORDBERG GRINDING MILLS and 37 SYMONS® CONE CRUSHERS for processing TACONITE in the Lake Superior Iron Ore Region...

SYMONS® CONE CRUSHERS and NORDBERG GRINDING MILLS have long proved their efficiency, dependability and economy in the profitable reduction of ores and minerals the world over. In the case of *TACONITE*, one of the hardest and toughest of all ores to process, the mining fraternity again depends on Symons Cone Crushers and Nordberg Grinding Mills for the economical production of large tonnages of fine crushed and milled product . . . as evidenced by the fact that, following extensive tests and research in pilot plants, 37 Symons Cones and 70 Nordberg Rod and Ball Mills were recently ordered for delivery to the mammoth reduction works now under construction in Northern Minnesota.

The thirty-seven Symons Cone Crushers . . . all Super Heavy 7-foot types, have been given the difficult assignment of secondary and tertiary crushing of the hard, tough Taconite Iron Ores. The seventy Nordberg Rod and Ball Mills were selected to meet the exacting requirements for primary and secondary grinding. Included are 33 rod mills—twenty-nine 10′ x 14′ units and four 10′ x 16′ units . . . as well as a total of thirty-seven 10′ x 14′ ball mills.

Thus, in Taconite operations . . . *as in all of the great ore and industrial mineral operations the world over . . .* NORDBERG MACHINERY is the outstanding preference among leading producers for processing great quantities of finely crushed and ground product at low cost.

Write for further information on the machinery you need.

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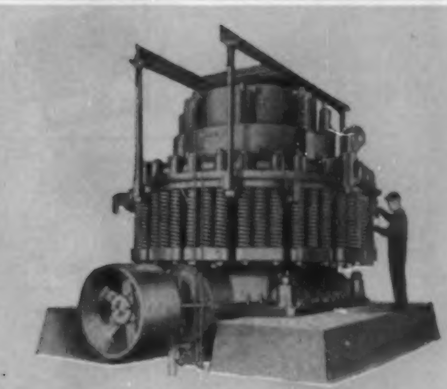

SYMONS CONE CRUSHERS . . . *the machines that revolutionized crushing practice* . . . are built in Standard, Short Head and Intermediate types, with crushing heads from 22″ to 7′ in diameter, in capacities from 6 to 900 tons per hour. Shown is a 7′ Super Heavy Unit as used for Taconite service.

NORDBERG GRINDING MILLS are built in ball, rod, tube, pebble and compartment types for practically all wet and dry grinding operations. Shown is one of the 10′ x 14′ Ball Mills for Taconite service.

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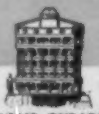

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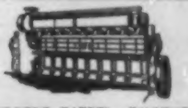
NORDBERG MINE HOISTS



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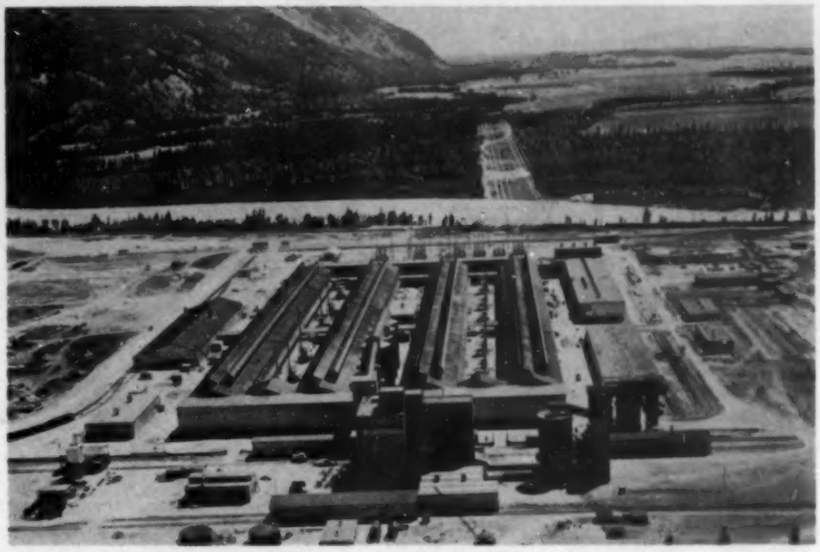
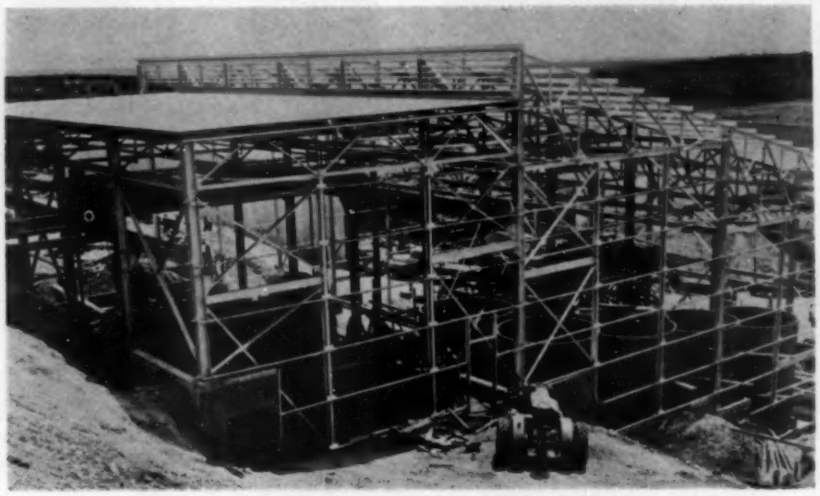
Anaconda Aluminum Co. Opens Montana Plant



Nation's newest primary aluminum producer was formally opened August 15 at Columbia Falls, Mont. The $65 million plant is owned by Anaconda Aluminum Co., first new company to enter aluminum production in the U.S. since 1946. Production lines are expected to reach rated capacity of 120 million lb annually by Jan. 1, 1956. High tension lines visible at top of photo lead to Hungry Horse Dam, 7 miles away. Power from this dam which was completed in 1952 made possible location of Anaconda's plant.



AEC Expands Uranium Plant

This grind leach building is part of $2 million uranium ore reduction mill construction for the AEC at Monticello, Utah. Contractor is H. K. Ferguson Co. Changed ore buying schedule at Monticello depot revises deductions for ores with more than 6 pct lime. Change is only at Monticello and is designed to fit the process methods at that plant.

Seismetron Aids South African Rock Burst Study

Saving miners' lives is the aim of a cooperative effort involving South African mining interests and the Liberty Mutual Insurance Co. The Seismetron, invented by Liberty Mutual loss prevention engineers, listens to rock under strain and helps foretell collapse. Rock bursts and heat are the most serious problems in the ultradeep mines of the Witwatersrand district, and it is hoped that this new device will reduce the unexpectedness of rock bursts. The Seismetron will also aid in research to determine what mining methods lead to rock bursts.

Liberty Mutual developed the instrument, sometimes called the microseismic detection apparatus, primarily to detect unsafe roof conditions during tunnel construction. Apparatus consists of a geophone to be inserted in the tunnel wall or pillar and an

amplifier to magnify the amount of micro-seismic activity. With a few weeks' training a man can use the equipment to find out if the tunnel roof or mine back is in static equilibrium; if it is active; if activity is increasing and approaching instability; or if failure is incipient. Developers of the instrument point out that it is not possible to predict the exact time of failure. The Seismetron is made by Walter Nold, 24 Birch Rd., Natick, Mass., under direction of F. J. Crandell of Liberty Mutual.

A cooperative research project sponsored by both Government and operating interest in South Africa is studying the whole problem of rock bursts. Work already reported shows that pillar shape, as well as percentage of seam extraction, largely determines burst probability. At one mine alone 694 rock bursts occurred in a six-year period. Averages range from 0.5 to 3.0 rock bursts per 1000 sq fathoms (36,000 sq ft) stoped.

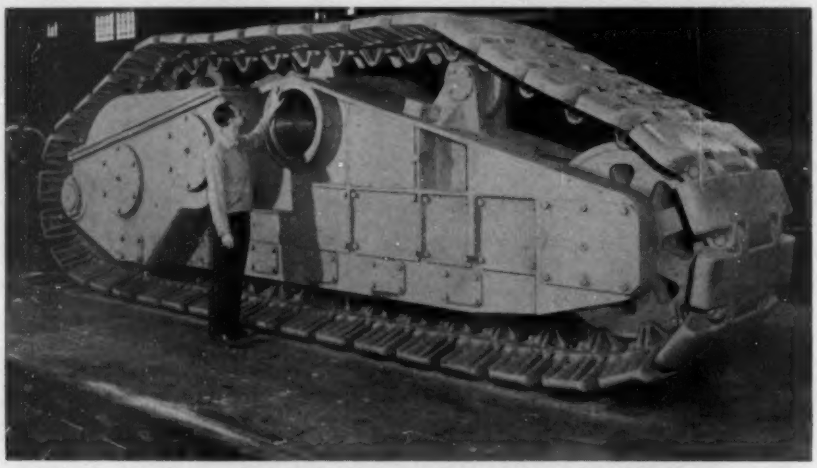
Marion Erects World's Largest Land Vehicle

One-Man Control on 60-ton Coal Shovel

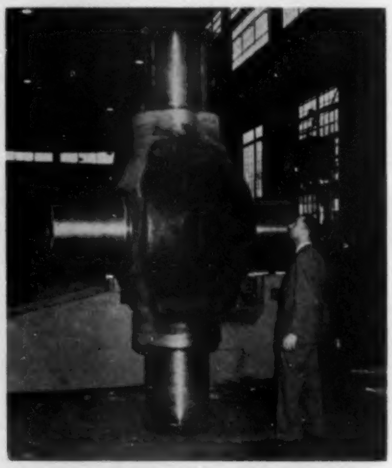
Pictures shown here tell part of the story of the Marion 5760 coal stripping shovel being built for Pittsburgh Consolidation Coal Co. Biggest land vehicle in the world, it will be 50 pct larger than existing equipment. Total weight of the giant is 5½ million lb, including 1 million lb of ballast.

Actual parts under construction make a more dramatic story than did the earlier artist's conception of the machine. Marion Power Shovel Co. hopes to complete the machine late this year. In operation the unit will move about 100 tons of overburden every 50 sec.

Lower frame of mammoth model 5760 has hole large enough for hollow centerpin that houses office-type elevator to carry 1000 lb or three passengers.



Each of the eight crawlers weighs 50 tons. Size of individual 840-lb shoes may be compared with man standing alongside.



One of the four-way axles. Entire machine will weigh 5½ million lb.

Mining Equipment in the News

ABOVE: Small shuttle cars like this one at Moab Mines in Utah are helping mechanize Plateau uranium mines. LEFT: First three of these Kenworth 803, 40-ton two-axle dump trucks went to Kaiser Steel Corp.'s Eagle Mountain iron mine in Southern California. Body capacity is 24 cu yd, heaped load 28 yd. Truck has 300 to 500 hp.

American Potash & Chemical Corp. To Utilize Rhodesian Lithium Ore

American Potash & Chemical Corp., already active in lithium production through its plant at Trona, Calif., has released further details on the new plant near San Antonio, Texas. Feed for this plant, unlike the Trona operation, which treats brines, will be lithium-bearing lepidolite.

American Potash, together with Selection Trust Ltd. and American Metal Co., has an interest in what is believed to be the world's largest high grade deposit of lepidolite at Bikita, Southern Rhodesia. More than $2 million will be invested in the Bikita properties, and nearly 11,000 tons of ore have been stockpiled already.

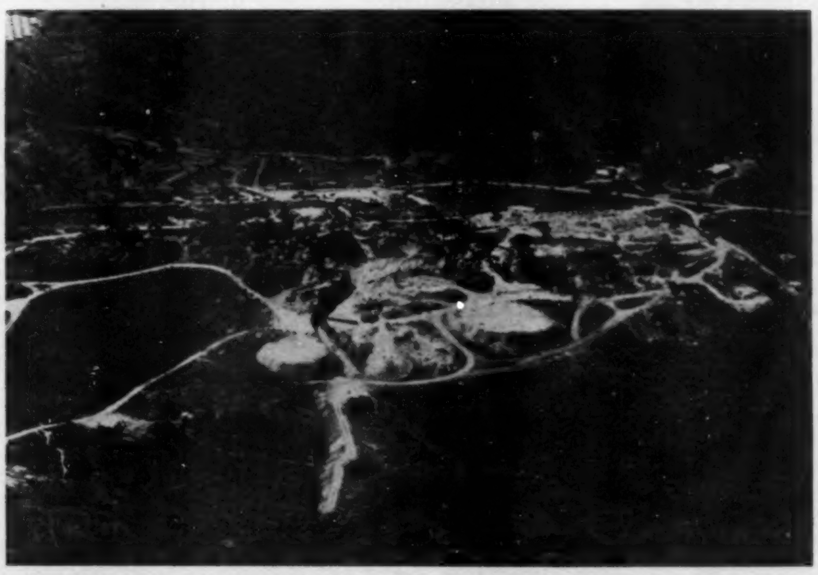
A new company, American Lithium Chemicals Inc., 50.1 pct owned by American Potash & Chemical Corp., is building a $6.6 million plant on a 200-acre site 7 miles from San Antonio to treat the ore from Bikita.

Search for a plant site for producing lithium hydroxide from lepidolite revolved about three considerations: limestone, water, and fuel. The San Antonio site offered nearby limestone quarries, ample water supply at 600-ft depth, and natural gas fuel from Texas fields.

The process mixes fine ground lepidolite carrying 3 to 4 pct lithium oxide with limestone prior to roasting in a rotary kiln. Calcining results in soluble lithium and potassium salts, which are then water-leached from the kiln discharge. Recovery of lithium hydroxide is carried out by a series of concentration and evaporation steps.

During research on lepidolite ore from Southern Rhodesia at main plant of American Potash, Trona, Calif., lepidolite samples are inspected by (left to right) Harold Mazza, assistant director of research; Robert Craig; and Julian Phillips, associate director of research. Studies at Trona included construction of pilot plant as basis for new San Antonio operation.

Although both the company's source materials are unique—dry lake salts and lepidolite—the new operation and the continuing one at Trona will make American Potash one of the world's largest lithium producers.



Lepidolite ore is mined from this hill at Bikita, Southern Rhodesia. Main quarry is at left center. Selection Trust Ltd. is responsible for technical management of Bikita. This London firm and its associates hold 50 pct of the stock. Other stockholders are American Potash, 21.5 pct, and The American Metal Co.

URANIUM FEVER, title of a Warner Bros. short movie subject being released nationally, is symptomatic of the interest in things atomic sweeping the country. Week-end prospector and industrial firm alike had the fever, but storm warnings began to show as news of recent weeks included items on atomic power, a hint that overproduction of the basic metal might be possible, and a crackdown on stock speculation. Whether the fever was still rising was anyone's guess—but the patient's pulse was rapid.

A rough count showed nearly 50 atomic reactors announced or building across the world. Many plans were revealed in the wake of the first commercial atomic power generation, which took place when Niagara Mohawk Power Corp. tied into the reactor at the GE-operated Knolls Laboratory. The reactor at this AEC lab is a prototype of the one for the second atomic submarine, the *Sea Wolf*. The sub itself was launched soon after the power demonstration, and within a month the AEC was talking about atom-powered planes.

Information was the primary goal as utility companies, engineering firms, and groups of research laboratories teamed up to plan reactors. It appeared that without this thirst for a closer look at the possibilities of the atom many would not have gone into atomic power so soon. Many if not all the projects would have to have a big slice charged off to research if the books were to balance. A liberalized policy on information from the AEC was part of the picture, as firms seriously interested in the field were being taken behind the curtain for the necessary know-how. Internationally, interest was stimulated by the conference on peacetime uses at Geneva that followed on the heels of the Big Four talks there. How this peacetime usage was going to affect demand for the metal uranium was still hazy. Informed guesses were possible as to the amount of metal needed to start a reactor, and even how much one might require over the years. The jokers lay in three questions: just where will atomic power stand economically, what are the possibilities of the breeder reaction, and will reactor wastes be an expense item for disposal—or will they prove a profitable byproduct eventually? Dollars and cents data were still pretty hazy.

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TORONTO brokers jumped and uranium stocks took a sharp cut when the Canadian Government announced it would not sign *special price* contracts with uranium producers after Mar. 31, 1956 (and only if producers could get rolling by 1957). Canada would still buy the metal, but at the regular $7.25 per lb. Promoters with high grade properties might have lessened profit margins, but those with low grade ore in sight faced tough financial problems. Even if development of the Blind River district had so far moved with almost indecent haste it was nothing to the rush to get under the deadline that was about to take place. U. S. sources refused to concede that there was any fear of uranium overproduction, but the AEC statement a few days earlier that the U. S. had become one of the world's major producers seemed not unrelated to the Canadian caution.

The mineral that clicks—if you have the right counter—seemed to be everywhere as the roster of reported uranium finds grew almost daily. Two points in South America, an increasingly large area in Australia, and above all an ever-widening region in the U. S. drew prospectors. In this country the term *Colorado Plateau* was being stretched pretty far to cover most of the area between the Canadian and Mexican borders. News ranging from *hot* prospects to actual production came in from California, Idaho, Nevada, and southeastern Arizona. Latest center in the search was Texas, where a find near San Antonio was spurring talk of a mill. Sidelight to the latter discovery was even closer interest in mining by oil companies.

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CRACKING down on speculation, the Securities and Exchange Commission is about to put into effect revised regulations for stock issues under $300,000, hitherto covered by regulations "A" and "D." Major objective of change is to see that money raised actually goes into mining and that the investing public "has a better deal than they had in the past year or two." New rules, subject of a public hearing in August, place U. S. and Canadian issues on same footing, continue to require filing of notification and offering circular except for issues under $50,000. Securities offered for sale will now have to be approved by the state (or Canadian Province) where property is located. Safeguards for the investor require placing funds in escrow for return to subscribers unless 85 pct of issue is sold within six months, and put the SEC in a position to get more information if necessary. Several uranium issues were recently held up over improper filing and insufficient data. Not only should the rather belated action help end some unwise and useless speculation, but it goes far to end the name calling back and forth over the Canadian border.

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MINE-MILL became first target for the Communist Control Act of 1954 when Department of Justice officials asked Subservices Control Board to find the International Union of Mine, Mill & Smelter Workers a Communist-dominated organization. Choice of a union for first action was no accident—others may be tagged if this case goes through. One newspaper pointed out that a file of copies of the Communist *Daily Worker* yielded an almost complete history of Mine-Mill; *The Daily Worker* showed a tender interest in the union. One possible snag to Justice Department plans lay in recent Federal Court decisions that have placed the burden of proof strongly on the Government side in so-called Fifth Amendment and perjury cases involving hearings on communism. The judicial side of Government was cautioned to observe due process and to stress direct rather than circumstantial evidence. If you want to call someone a "Red", you had better have the documents ready, they warned.

TRENDS

WHILE mining was getting close attention from various other Government agencies on both sides of the border the Congressmen didn't neglect the industry completely in the closing days of the last session. Curbing the abuse of mining land laws, while not interfering with legitimate mineral activities, was the goal of bill that went to the President for signature. Senator Malone (R. Nev.) raised the only opposition to the bill in the Senate. Action was termed long overdue by many observers, who pointed to an article in *Collier's* last year as evidence that misuse of mining laws to locate claims for other than mineral purposes had become an open shame. The bill had support of the American Mining Congress and various state mining associations. Holders of valid claims will have full rights to surface resources needed to carry out mining activity, and patenting will lead to full title, surface and subsurface, as in the past. But U. S. will have right to use and manage surface resources if this doesn't interfere with mineral activities. A Colorado attorney summed up the situation, "No legislation is a panacea for all of the world's problems. This legislation, however, appears to represent a sensible and equitable approach to a long-festering problem."

Two other bills passed at this session would permit exploitation of mineral resources of public lands withdrawn for power development and permit mining under the mining laws of uranium within lignite seams.

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COAL mining got its biggest recent boost from another part of the mining industry—aluminum—a development that was no surprise to readers of MINING ENGINEERING. Major part of Reynolds Metal Corp. plans for increasing primary capacity to 1.1 billion lb per year is a 200 million-lb aluminum plant in the Ohio River Valley. Power for the plant will come from a 300,000-kw coal-burning power station, and fuel for the power station will come from a million ton per year mining operation on Reynolds-owned coal lands.

Reynolds is not alone in turning to coal as a power source for aluminum production—Olin Mathieson and a combination of St. Joseph Lead Co. and Pittsburgh Consolidation Coal Co. are also actively interested. The latter combination, while new to aluminum production, would couple wide metal production experience with the technical background of the nation's largest coal company.

All these projects visualize integrated mine-to-potline production, gaining maximum economic advantages of integration and stabilized production. A penetrating analysis by Arthur F. Johnson of the factors that make coal the economic power source for future aluminum expansion, *Coal as a Source of Power for Production of Aluminum*, appeared in the April 1955 issue of MINING ENGINEERING. An earlier article by Mr. Johnson (MINING ENGINEERING June 1954) covered the transportation cost factors that establish the coal producing areas as logical sites for electrometallurgical plants.

Study of company announcements and the articles by Mr. Johnson, who is with Olin Mathieson, reveals the factors favoring coal as the power source:

► Coal mining can be tailored to maximum efficiency, not to the whims of customers.
► Continuity of coal production is possible, free from ups and downs of market situation.
► Coal would flow almost continuously from mine to tipple to powerhouse, with savings in transportation, handling, and cleaning. Overhead would also be saved in the combined operation.
► Powerhouse-to-potline busbars would save power transmission capital costs and charges.
► Transportation costs for incoming bauxite would be reduced at a site on or near navigable water connected to the Gulf and Caribbean area.
► Location of plant near the market center of the U. S. (true of coal mining area) reduces shipment cost on outgoing metal.
► Coal producing areas have favorable labor and tax conditions.
► Import duties on refined aluminum are avoided.

Related to the new Reynolds plant will be other expansion including enlarged bauxite production. Source for bauxite is the Caribbean, making the Gulf Coast the logical site for new aluminum plants. Kaiser Aluminum & Chemical Corp. is also seeking a site on the Gulf Coast for a new alumina plant, and Aluminum Co. of America is to build a half million ton capacity alumina plant. Overall, the picture looks as if the once-proposed "third round" of primary aluminum production increases is coming about piecemeal. In all, 400,000 tons of new primary facilities are under construction or actively considered by the industry. Coal and lignite are playing a major role in this program.

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A CALL for colleges to quit "lambasting" high schools "for the poor job they are doing" was coupled with a proposal to undertake a national plan of college and high school cooperation. The speaker was J. F. Downie Smith, dean of engineering at Iowa State, addressing the 63rd annual meeting of the American Society for Engineering Education. At the same meeting Watson Davis, director of Science Service, was optimistic in saying that there was a surge to science among the nation's youth. Just a short time later Allison C. Neff, incoming president of the National Society of Professional Engineers, sent a letter to 800 publishers of daily newspapers asking the help of the press as a first step to "stem the tide of students away from elementary mathematics, physics, and chemistry."

Also covered at the ASEE meeting was the *Report on Evaluation of Engineering Education, 1952-1955*. Result of a project financed in part by contributions through EPCD, Engineering Foundation, General Electric Co., and National Science Foundation, the report covers the whole field of college, precollege, and post-graduate education related to engineering. Those interested in the complete report may obtain copies from The American Society for Engineering Education, University of Illinois, Urbana, Ill., at 25¢ per copy.

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Run-of-Mine SCALPING SCREEN

Single pieces weighing as much as four tons . . . hundreds of pounds of sticky material adhering to screen body . . . large volume requirements. These are the demanding conditions under which this screen is setting new performance standards.

Here are some of the many features which enable this screen to meet severe duty with *minimum maintenance:*

Extra-Large Bearings (largest ever installed in an A-C screen) withstand punishing loads. Bearing life is extended, replacement less frequent.

Simplified Two-Bearing Mechanism reduces maintenance time and cost.

Cartridge Mechanism can be pulled out after merely removing sheave and four bolts.

Sturdy Channel Construction features 12-inch I-beam deck support.

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For information on this extra-heavy-duty screen and other Allis-Chalmers screens applicable to your operation, see your A-C representative or write Allis-Chalmers, Milwaukee 1, Wisconsin.

Designed to Team Up With Primary Crushers to handle the toughest job on any mining flow sheet.

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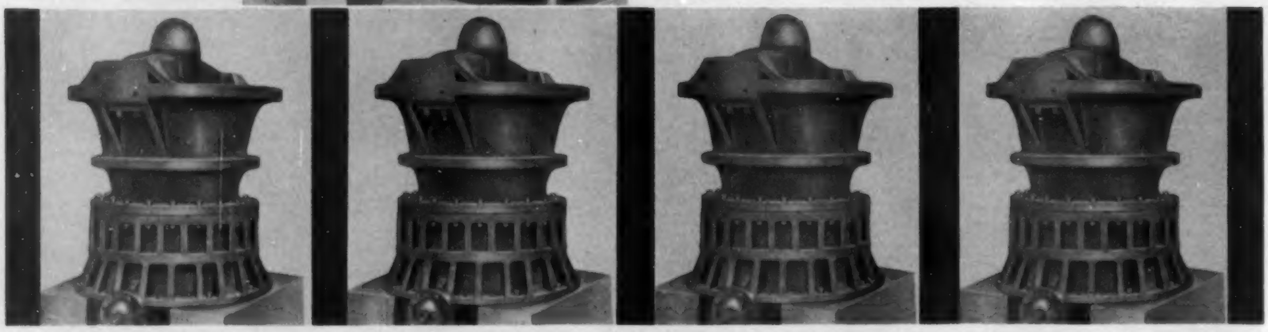
Erie Mining uses Traylor's Experience to get Economical Production of Taconite Ore

Traylor Now Building Giant Primary Crusher

WITH 60" RECEIVING OPENING AND 120" DIAMETER CRUSHING HEAD



. . . plus four 36" Gyratories for Erie Mining Company's Aurora Project

Profitable production of iron ore from low-grade Taconite calls for the most modern, efficient methods and equipment. That's why Erie selected Traylor Gyratories for both primary and secondary reduction of the extremely hard Taconite-bearing rock.

Traylor is now building for Erie a huge 60" Gyratory Primary Crusher which is higher than a three-story house and weighs more than a million and a quarter pounds . . . this giant TC Gyratory is the seventh of its kind to be built by Traylor. Chunks of ore the size of a flat-top desk dumped into this crusher at the rate of 4,400 long tons per hour will be reduced to 12". In a 15 hour day, this TC will crush 66,000 long tons of rock. Four 36" Traylor Gyratories will take the 12" ore from the crusher and reduce it to minus 5" in the secondary reduction operation.

For the past 50 years, leaders in the mining industry throughout the world have turned to Traylor for the most efficient equipment to help them keep pace with advanced mining methods.

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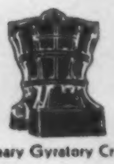
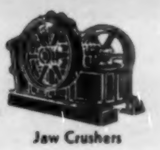


Primary Gyratory Crushers

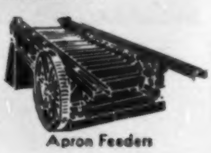
Rotary Kilns

Secondary Gyratory Crushers

Ball Mills



Jaw Crushers



Apron Feeders

MINING engineering

DRIFT

RARELY does one have the good fortune to observe an accelerated replay of some important historical event, but growth of the uranium industry has presented the history of American mining in the brief span of five years. If a few details of the more modern techniques are omitted, the entire pattern of the first 40 or 50 years of mining in the U. S. has been laid before us again. Almost every detail of the two periods is the same, but the rapidity of the latest development has been such as to cloud the relation between individual events.

In June we had the pleasure of traveling some 1200 miles around the Plateau and believe that this comparison, with some variations, is legitimate. We are deeply indebted to Sheldon Wimpfen, Grand Junction operations manager of the AEC Raw Materials Div., and officials of Climax Uranium Co., for this most enlightening tour. Unfortunately the trip covered only a small portion of the Plateau.

However, the time spent there was sufficient to convince us that the history of the Plateau should never have to be written. History is much too formal to convey properly the motives and emotions of one of the most important eras in the history of the world. The story of the first phase of mining raw materials for atomic energy should be a diary.

This does not live up to the standards we have set for the chronicles of uranium mining, but we kept notes of our travels just for the record.

June 1. Arrived Grand Junction. First of the uranium capitals, title now claimed by Moab and Salt Lake City. Town has really livened up since our last visit. Restaurants are jammed every night. Food and drinks are usually atomic or radioactive. Prices not too bad. Most neon signs are for stores supplying Geiger counters and engineering services.

June 2. Visited Climax Uranium office. Went with Tim McCandless, head of Climax mining dept., to principal company operations on Outlaw and Calamity mesas, 60 miles southwest of Grand Junction. This was one of the first uranium producing areas of the Plateau. Orebodies are small and a large percentage of mining is "gopher-holing." Back to Grand Junction late . . . visited Uranium Center and found offices clustered around a large bar and restaurant—one of the many rumor centers. One uranium tycoon describing his recent stock acquisitions to another bragged, "I was able to close a big deal this morning and picked up 53,000 shares of Dry Gulch Uranium." His friend emptied the shot glass, chased it with a sip of beer, and replied with disinterest, "That's nothing." He wiped his mouth with his coat sleeve. "I've got eight dollars worth."

June 3. Went through Climax Uranium. New countercurrent acid leach plant for uranium replacing old batch plant. Sampling and crushing plant expanded. Very worth-while trip.

June 4. Spent day at hotel reading a $2.00 University of Mexico geology report that cost $4.50 in a local prospectors service store. Of course availability is worth something! That evening attended Annual Dinner-Dance given by the Ladies' Auxiliary of the Colorado Plateau Section at the invitation of Mr. and Mrs. Sheldon P. Wimpfen. Encountered usual high standard of western hospitality and graciousness. Attendance was proof of the interest found among members of this group, which is responsible for its rapid growth.

June 6. Sheldon Wimpfen arranged a trip through portions of Utah mining areas. Carl Appelin of the Access Roads Div. added us as a passenger on his regular swing to check progress on the construction of access roads.

Stopped at shaft sinking project of the Uranium Prospectors Co. in the Yellow Cat district. Sinking a 325-ft shaft that will cost about $125 per ft. Conversation with G. J. Ballard, operation superintendent, was most informative, but as we started to leave he expressed concern about our reviewing his new book *Uranium Prospector's Guide*. We told him the review would appear in the July issue. This is reported to be a best-seller.

Stopped at Temple Mountain operation of Consolidated Uranium Co. and had the experience of going down a 235-ft Calyx drillhole shaft. Received shocking introduction to safety practices on the Plateau. Stepped out of ore bucket onto landing to find shaft station was actually ore chute for loading buckets. Fortunately, Speed Graphic camera we were carrying caught on top of chute and did not follow the body down . . . . Two days later and many hundreds of miles of unbelievable roads. Shaved. Visited AEC mill at Monticello. Found no advance information had been sent out regarding our arrival. Took pictures outside gate.

June 9. Peak in tour. Spent evening with Charles Steen and his gracious wife . . . beautiful home high on a mesa overlooking Moab. The Uranium Subsection of the Utah Section held a meeting on that evening at Arches Cafe in Moab, but prior commitments prevented our attending. Talked to Dave Coolbaugh, active member of the subsection. Subsection is a fast-growing organization and rightly so—Moab rapidly becoming important center of uranium production on the Plateau. With building of Steen's new mill, area will expand greatly.

Mining in Big Indian Wash, 40 miles south of Moab, is on upswing. Such operators as Paul Henshaw of Homestake Mining, W. H. Love of U & I Uranium, and Virgil Bilyeu of Utex Exploration Co. will assure Big Indian a prosperous future.

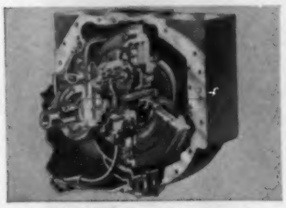
June 10. Returned to Grand Junction.

Our travels on the Plateau were not as extensive as we would have liked, but just a little of the fever rubbed off, so in a future issue there will be more on this subject. We still have more inquiring and looking to do to round out the details in a longer and more complete article.

Charles M. Cooley

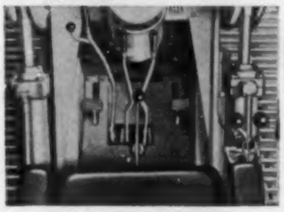
"BIG-PRODUCTION" FEATURES OF THE NEW NO. 955 AND NO. 933

40-DEGREE BUCKET TIP-BACK AT GROUND LEVEL. Large tip-back at low bucket height results in larger loads every pass—bigger production per day!



NEW OIL-TYPE CLUTCH. Stands up under continuous, repeated use. Cuts maintenance costs and time two ways: (1) Clutch adjustment, while easy, is seldom required. (2) Plate replacement is often unnecessary even at engine overhaul.

Also helps step up production with easier shifting for operator.



CONVENIENTLY LOCATED LIFT AND DUMP LEVERS. All controls are within easy reach—bucket controls are a one-hand operation!

"DESIGNED-IN" COMFORT. Operator sits high in a comfortable seat, with excellent visibility of all bucket conditions.

PERFECT BALANCE. Weight distribution, engine horsepower and bucket capacity are balanced so that the full length of the track stays on the ground with a heaped load in the bucket.

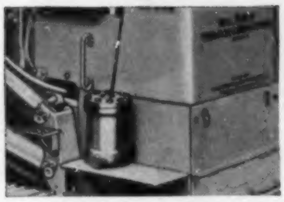
NEW 3-GROUSER TRACK SHOES. Tested and proved on tough jobs, they deliver better traction—longer life.

OPTIONAL STARTING. Your choice of 6-volt electric starting for starting engine or 24-volt direct electric starting—from the seat, either way.

VERSATILE ATTACHMENTS. Your job range is increased by a variety of buckets and other useful attachments.

BRIEF SPECIFICATIONS	No. 955	No. 933
Flywheel HP at sea level	70	50
Bucket capacity, cu. yd.	1½	1
Bucket tip-back at ground level, degrees	40	40
Bucket tip-back at max. lift, degrees	47½	48
Dumping height (center of hinge pin to ground)	128"	118½"
Weight (approx.) lb.	21,480	15,500

TRAXCAVATORS



MODERN HYDRAULIC SYSTEM. Full-flow hydraulic system filter protects moving parts against abrasive particles in fluid. Filter handily located for easy replacement of element.

Hydraulically balanced vane-type pump insures delivery of full volume and pressure of oil for thousands of hours. Operating valves in tank provide maximum protection against damage and dirt. Closed hydraulic system—no vents or breathers—prevents entrance of dirt.

HIGH REACH. Plus strong box section arms for rugged service. Box-type cross brace prevents twisting or bending.

PLENTY OF POWER. Power is ample to "bury" the bucket and provide fast lifting action and positive dumping under all load conditions.

BALANCED UNITS for BIGGER PROFIT!

Designed from the ground up as excavating and loading machines, these two new CAT*-built Traxcavators* are balanced for bigger production at lower cost. Built and backed by *one* manufacturer, they give you all the advantages of single manufacturing responsibility. With practical, advance-design features, they're engineered to *outproduce* ordinary tractor-shovels of the same capacity. You'll find these units the handiest tools in your line-up. Get the money-making picture from your Caterpillar Dealer—ask for a demonstration!

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

CATERPILLAR*

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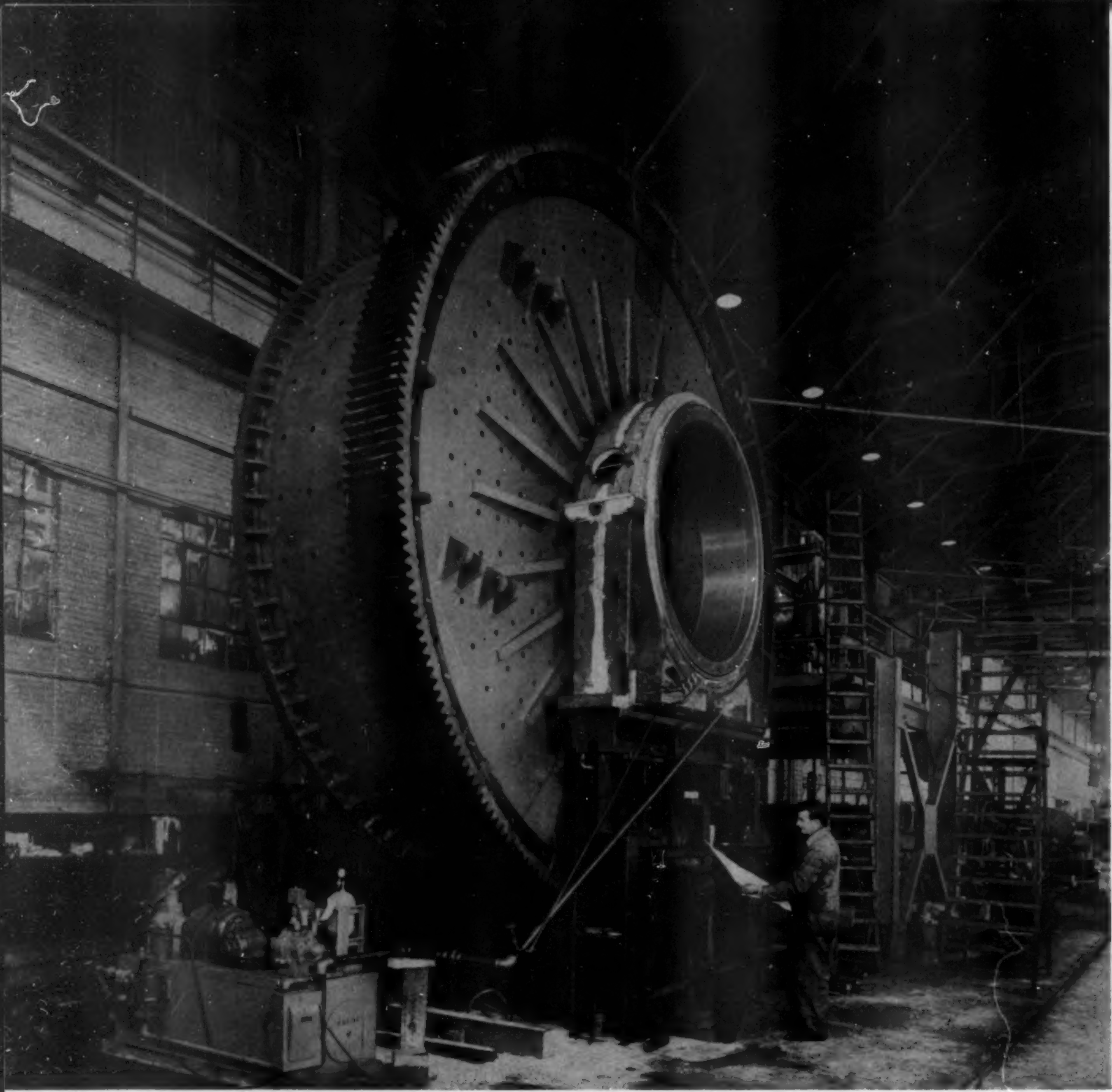
NEW BIG-PRODUCTION TRAXCAVATORS

ANOTHER EXAMPLE OF CATERPILLAR LEADERSHIP IN ACTION



Aerofall Mill Finds Increasing Application

Dry grinding without balls is feature of this mill now in use in three countries on two continents. Materials being ground commercially include iron ore, gold ore, asbestos rock, and slag.

by Rixford A. Beals, Associate Editor

NEW large beneficiation plants have been using an almost standardized crushing and grinding flowsheet. Typically a primary gyratory is followed by several stages of fine crushing and grinding is often carried out in a rod mill operating ahead of one or more ball mills. The clearly labeled trend is to an increasing number of stages with a decreased reduction ratio per machine. Current Aerofall mill installations represent a complete reversal of this trend—one mill replaces the several stages of crushing *and* grinding a more conventional flowsheet would call for.

The basic feature of the Aerofall mill is continuous dry crushing and grinding of ore upon ore, combined with classification of the ground material by passing air through the mill at a controlled rate. To cite an example, one mill is reducing −18 in. run-of-mine ore to 60 pct −200 mesh in a single operation. Physically the mill is characterized by a high ratio of diameter to length, and it uses little or no ball charge. Breaking rock with rock and grinding dry are far from new ideas. The widely used pebble mill, and sized additions of coarse feed as utilized in Canada and on the Rand, are applications of the first idea. Dry grinding Krupp mills date back half a century.

Combinations of these ideas—dry grinding, autogenous crushing, and large diameter mills—have been attempted before but the results were inconclusive. In some cases development was interrupted, in others success came only in specialized applications. In the face of this background the first Aerofall mill installations represented considerable engineering courage. The designer was putting all his eggs into one basket, into a unit that promised to both crush and grind. That this has proven possible for a wide range of materials is shown in Table I.

Cost Factors Warrant Study

First factor in any comparison of units is simple to state but complex to analyze: *cost*. A machine which replaces several others immediately suggests savings through reduction of labor, of space, of maintenance, and of power consumption. According to the builders of the Aerofall this promise is met. One operator can handle a large plant, maintenance is stated to be low, and sharp power reductions overall are claimed.

More difficult to analyze and document are advantages realized in metallurgical results through differences in various grinding units. One difficulty is that the advantages or disadvantages will depend on the specific feed in each case. Many industrial minerals are dry ground, so this factor is unchanged in considering the mill, and any advantages in air classification can be realized also. More controversial are claimed advantages through selective grinding or lessened overgrinding. Proponents have some evidence that there are ores, industrial and metalliferous, where comminution provided by the Aerofall mill has inherent advantages aside from any consideration of costs. It is claimed that a higher degree of mineral separation is obtained, permitting improvement in grade of concentrate and/or reduced tailing loss; in the case of flotation ores better surface preparation is claimed to give increased efficiency from that process. It is quite possible that this mill may be chosen for an ore where early separation of natural slimes is advantageous (perhaps in the case of Plateau uranium ores) or where the combination of machine and ore characteristics makes a degree of selective grinding possible. In the case of the gold ore installation, see page 844, early figures suggest savings in thickening and filtration costs due to a reduced product of ultrafine slimes. In the iron ore plant improved concentrate grade with a lower tailing loss and/or coarser concentrate are hoped-for indirect benefits. Pilot plant test data on sulphide ores have shown a trend toward higher recovery.

Cost Figures

Material	Final Product Screen Analysis	Feed, tph	Direct Operating Costs Per Ton Labor, Power, Maint.
Quartzite	All −28 Mesh	500	$0.226
Uranium Sandstone	97 pct −20 Mesh	1000	0.119
Gypsum	85 pct −100 Mesh	500	0.197
Limestone	40 pct −200 Mesh	1200	0.20
Quartz Conglomerate Gold Ore	40 pct −200 Mesh	1250	0.132
Copper-Nickel Sulphide Ore	55 pct −200 Mesh	2500	0.094

Moisture and Ball Charge

Changes in ore character and in moisture content have been problems in autogenous mill design. It is stated that the Aerofall mill can tolerate up to 4 pct moisture without effect upon capacity or product. With heating apparatus for the air intake, the mill has reportedly ground ore up to 12 pct moisture. Flexibility as to feed make-up is also supplied, if necessary, by adding a ball charge of up to 2.5 pct of total mill volume. With such a charge ball consumption figures range less than 0.05 lb per ton.

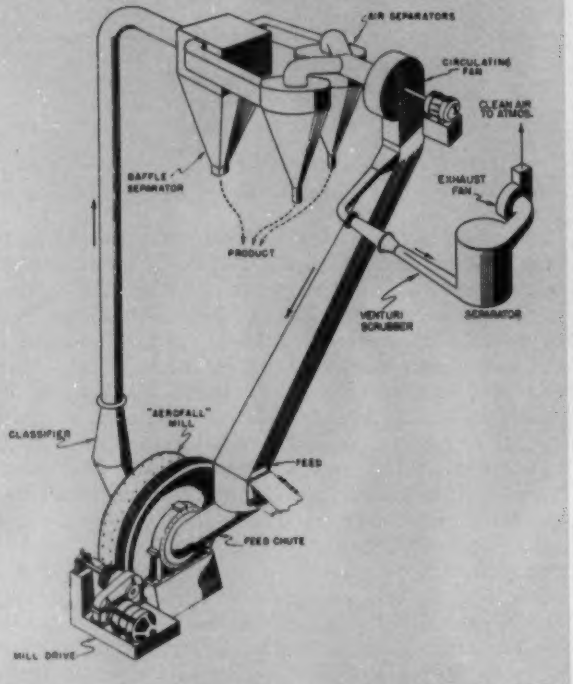
Capital cost is the final consideration. The most favorable situation would be a completely new in-

Table I—Typical Aerofall Commercial Milling Plants

Material	No. of Units	Mill Diam, Ft	Feed	Source of Ore	Capacity per Unit, tpd	Mill hp per Unit	Air hp† per Unit	Grind
Asbestos Ores	7	17	Secondary Crusher*	Open Pits	1000	400	400	90 pct —4 Mesh
	2	12	Primary Crusher*	Block Caving	300	150	150	90 pct —4 Mesh
Iron Ore	1	17	Primary Crusher*	Open Pit	3000**	500	500	—10 Mesh
Gold Ore	1	17	Run-Of-Mine	Underground	1000	500	150	40 pct —200 Mesh
Ferro-Silicon	1	7½	—6-in.	Furnace Product	50	50	25	All —48 Mesh
Quartzite	1	9	—10-in.	Open Pit	75	100	25	50 pct —200 Mesh
Metallurgical Slags	1	9	—24-in.	Furnace Product	50	100	25	60 pct —200 Mesh
and Linings	1	5	—10-in.	Furnace Product	20	25	15	—10 Mesh

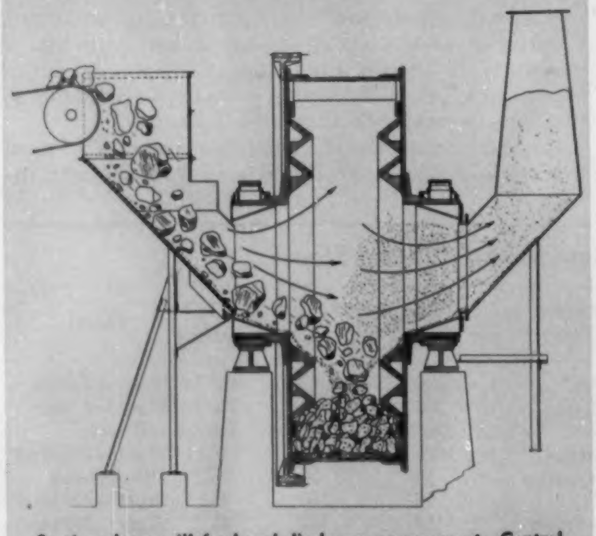
* Crusher product is mill feed. ** Long tons. † Air for product removal.

Aerofall Plant Installation



Drawing indicates typical components of complete Aerofall installation for dry crushing, grinding, and collection. Basic components are of standard design, but their arrangement may vary as shown by drawings on page 845.

Mill & Recovery System



Section shows mill feed and discharge arrangement. Control of air flow determines size of final product. Air circulation (see drawing above) is a closed system. Note that no balls are shown.

Iron Ore Flowsheet

FEED: Open-Pit Ore

Conventional	Aerofall
Primary Crusher	Primary Crusher
Secondary Crusher	
Tertiary Crusher	Aerofall Mill
Screens	
Rod Mill	

TO: Concentrating Plant

stallation where maximum savings in auxiliary equipment and structure could be realized. That the installed cost of this mill must be competitive overall with conventional circuits is indicated by the fact that one installation in Table I is a completely new plant, that one is an extension of present capacity, and that another replaces existing sections.

Final evaluation of this mill will depend on performance reports from present installations. But it seems safe to assume that at an early design stage in future mill projects engineers will carefully compare the advantages of the Aerofall-type mill with those of presently more conventional circuits employing multiple stage crushing and grinding.

History of the Design

AEROFALL mill development had its beginning in the late 1930's. Despite the depression which was then almost at its worst, so far as the base metals industry was concerned, the management of Consolidated Mining & Smelting Co. of Canada started a comprehensive program of research for the purpose of testing various theories of comminution. The objective was to improve performance of the then existing mill equipment. During this program, which was interrupted by the onset of World War II, much was learned about the nature of comminution which formed the basis for new theoretical approaches to the problem.

D. Weston, the inventor of the Aerofall mill, participated in this program as a testing engineer, and later, while serving in the Canadian Army, had time to complete the formulation of the theories

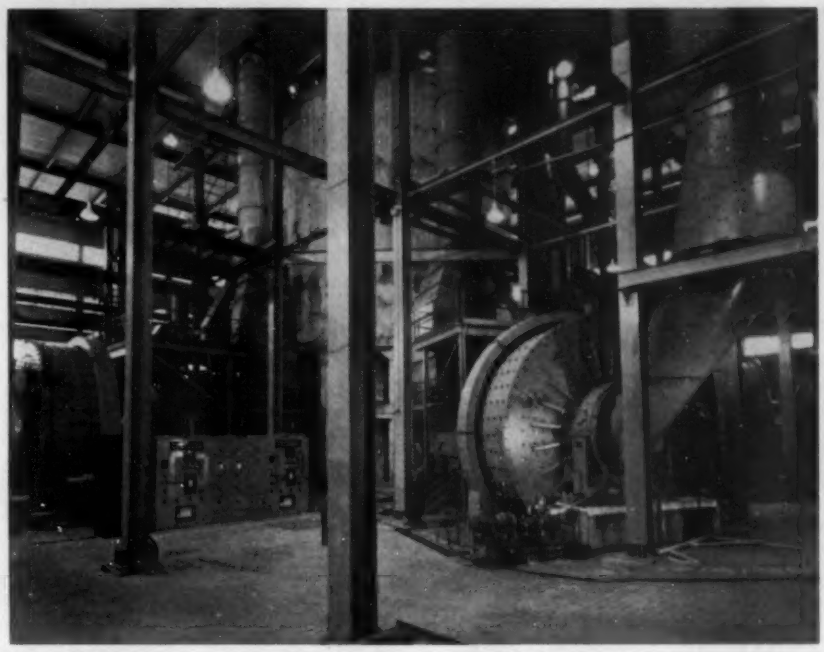
Gold Ore Flowsheet

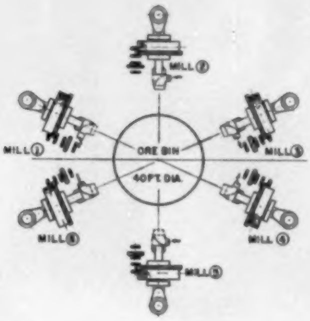
FEED: Run-of-Mine

Conventional	Aerofall
Primary Crusher	
Secondary Crusher	
Screens	Aerofall Mill*
Primary Tube Mills	
Secondary Tube Mills	

TO: Cyanide Plant

ASBESTOS PLANT: View of the Normandie plant of Asbestos Corp., Black Lake, Que., shows three of the 17-ft mills used. Six mills are arranged in a radial pattern around a 40-ft circular bin.





Plan shows the unique arrangement used in the Normandie asbestos plant for a capacity of 5000 tpd.

suggested by the work which had been done. On discharge from the Army, the inventor was given extended leave of absence from Consolidated Mining & Smelting Co. to pursue the theories which he had formulated and to put them to practical test.

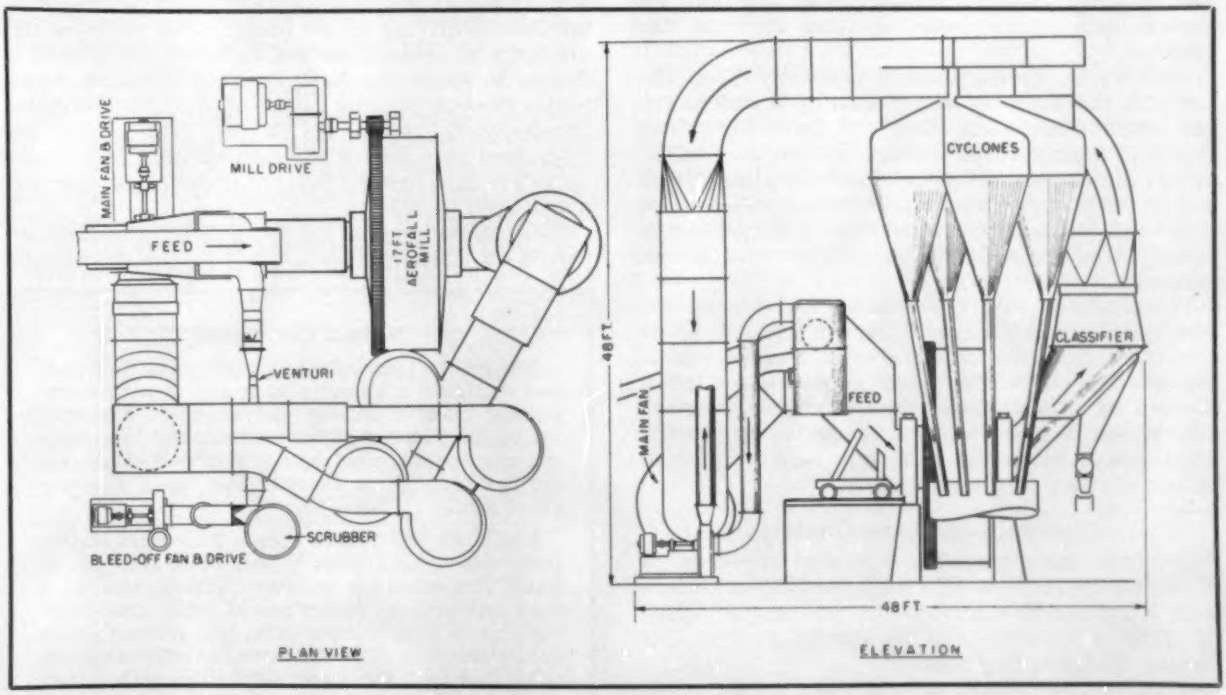
Serious development work on the Aerofall mill was begun following World War II at the Canadian Bureau of Mines in Ottawa. The mill used in this work was 5 ft diam and capable of reducing 10-in. feed to as fine as 75 pct —325 mesh.

First commercial installation was at a gold mine in northern Canada. The plant operated only a very short time because it was found there was insufficient ore to maintain production. However, much valuable data was obtained so that correlation between the test and commercial units could be started.

Pilot mills were then built which incorporated new ideas developed from theories and from operation of the first pilot mill.

Other commercial units followed, and in 1950 the largest unit constructed to date, a 17-ft mill was built for a large asbestos producer. This unit went into operation in 1951 and gave fairly complete information on correlation of capacities of the various size units. Many of the problems in air handling and mill control were solved from this installation.

After this installation other commercial units were gradually built, installed, and put into operation. The diverse materials handled by these installations created new problems, but the Aerofall mill is now handling nearly every type of ore, and under widely varying conditions.



Two drawings above show Aerofall installation at a South African gold property. One mill in this plant reduces 800 tpd of run-of-mine ore to 40 to 50 pct —200 mesh.

Pend Oreille Mines & Metals Co.

Latest Mill Reflects Changes Over Four Decades of Mining

by J. C. Crampton

GRADUAL shifts in the center of ore production have dictated three moves for the Pend Oreille Mines & Metals Co. plant. Capacity has grown from 300 tpd to the present 2400 tpd, and the gravity process used at the original Josephine mill has long since given way to improved flotation practice.

The Josephine mill, operated in World War I and converted to flotation in 1927, treated 200,000 tons of ore rating as high as 16 pct Zn. By 1935 extra ore handling warranted construction of a new mill on a lower level, and capacity was raised from 300 to 800 tpd.

To eliminate the necessity of carrying feed from the east side through workings under the Pend Oreille River, the East mill was erected 4 miles northeast of Metaline Falls, Wash. The first of three parallel units went into operation January 1951, the second eight months later, and the third in May 1954.

Built on flat terrain, the mill is readily accessible, and it is designed for safety, ease of maintenance, and efficient operation. Ball mill floors have been sloped to drain into the circuit, and the area under the flotation cells has been sloped in such a way that products are kept separate and returned to their respective circuits by float-actuated sump pumps. Work of cleaning up spill is reduced to a minimum.

The crushing plant is served by a 15-ton motorized crane and the ball mill bay by a 20-ton crane controlled from the catwalk by a hanging push-button. The 60-ft span of the flotation section is covered by a 3-ton hand-operated crane, and the cleaner section is served by a monorail. Two truck-ways run through the mill, one behind the ball mills, the other on the sump floor.

Conveying and Primary Crushing

Ore from underground is delivered at —3 in. to the coarse ore storage. Ore from the 2200 or surface level is trucked to a surface bin, sent to the 15x30-in. Traylor crusher, and discharged to the belt serving the secondary crushers.

J. C. CRAMPTON is Mill Superintendent, Pend Oreille Mines & Metals Co., Metaline Falls, Wash.

Secondary Crushing: Belt feeders under the coarse ore bins and stockpile are driven by General Electric ACA-type variable speed motors. All feeder and conveyor belt motors in the crushing plant are controlled from panels at the screen discharge point, where tramp iron warning lights and ammeters showing crusher load are also located. Conveyor belts are interlocked electrically by overload devices on the meters and by centrifugal plugging switches driven by the tail pulleys.

Hydrocone Crushers: Final crushing is done by two Allis-Chalmers Hydrocones with 60-in. mantles, each operating at 150 tph. Performing simultaneously they approach 400 tph as surges to the screen are minimized. With new liners the feed opening is 7 in.

The crusher head center is supported on a hydraulic piston, and take-up is adjusted by a reversing switch driving an oil pump. This removes the drudgery of take-up caused by wear and makes it simple to lower the head on rare occasions when tramp steel or packing causes stalling. A hydraulic accumulator, pre-set at 700 psi, gives protection from steel by allowing the feed opening to increase up to 3½ in. when the crusher pressure exceeds the normal 300 to 500 psi.

Four rubber mounts for the crusher, each held by two ⅝-in. bolts, permit a much lighter foundation

Mineral Occurrence

The galena is usually in coarse grained patches and stringers in siliceous rock and at patches replacing massive calcite. Advantage is taken of the massive nature of the lead mineral to make a coarse primary grind and float ahead of the regrind necessary to liberate the finely disseminated zinc.

Light red and yellow sphalerite occurs as disseminated grains, usually less than 1/16 in., as small discontinuous fracture fillings, and as a very fine grained saturation of rock. Zinc-bearing rock is usually dark gray, fine grained siliceous dolomite or jasperoid with the mineralization associated with the jasperoidal silica rather than the crystalline quartz.

Surface plant of the Pend Oreille Mines at Metaline Falls, Wash. Mill is on the left and underground belt discharges in the two bins and stockpile in the center foreground. Warehouse, machine shop, and electric shop are on the right. Adit shown on extreme left is the 220 level.

than would normally be required, as shock is absorbed rather than transmitted. Although the crusher weighs more than 26 tons and moves in its orbit nearly ½ in., the first set of mounts is still in service after four and one half years.

Screening Section: The two 5x12-ft double-deck low head screens are in closed circuit with the Hydrocone crushers, and feed can be split or diverted to each screen separately. It was believed that screen cloth with square ¾-in. openings would give the best ball mill feed size, but in practice pyramidal breakage of the ore tended to blind the screen, while another fraction of ore broke in slabs. A slotted screen was tried with marked improvement. Best results were obtained with an opening ⅝x5 in. and slots running across the screen. Table I gives size analysis of crusher products.

Grinding

The 1000-ton, 30-ft diam reinforced concrete fine ore bins discharge by gravity onto a 20-in. belt driven by a U. S. Varidrive motor. This belt in turn discharges onto a constant speed belt and across a Fairbanks Morse conveyor scale to the scoop box. The mill is fitted with a single scoop with Nihard lip.

Primary Grinding: The 10x8-ft dished head ball mills, manufactured by the Union Iron Works of Spokane, are driven by 400-hp synchronous motors with push-button control. Chrome-moly alloy breast liners weighing 27,000 lb are of shiplap type, and Nihard end liners, weighing 22,000 lb per set, have lifter bars at both feed and discharge ends. Launders discharging to the 7x28-ft Dorr HX classifiers are lined with concrete, and points of wear are built up during shutdowns.

Mills are charged with 4-in. balls by an overhead crane from boxes placed on stands close to the discharge end of the mill. See Table II for ball consumption and liner wear figures and Table III for power consumption breakdown.

Regrind Circuit: Two 7x48-in. Hardinge mills charged with 1½-in. regrind balls regrind the lead tails ahead of the zinc float. The two 60-in. Wemco spiral classifiers that close the circuit are elevated above the ball mills to allow most efficient use of floor space. Zinc cleaner tails and scavenger concentrate are also returned to these classifiers.

When three mills are running the density is dropped slightly in the primary circuit, and speed of the regrind mills is increased to handle the additional feed. Resistance inserted in the rotor circuit of the motors slows the regrind mills to customary speed when only two primary mills are running. A third 6-in. Hydroseal pump will be added to pump to either classifier or split the feed between them.

Figures based on analysis of final tailing will illustrate the increasing dissemination of zinc in the ore:

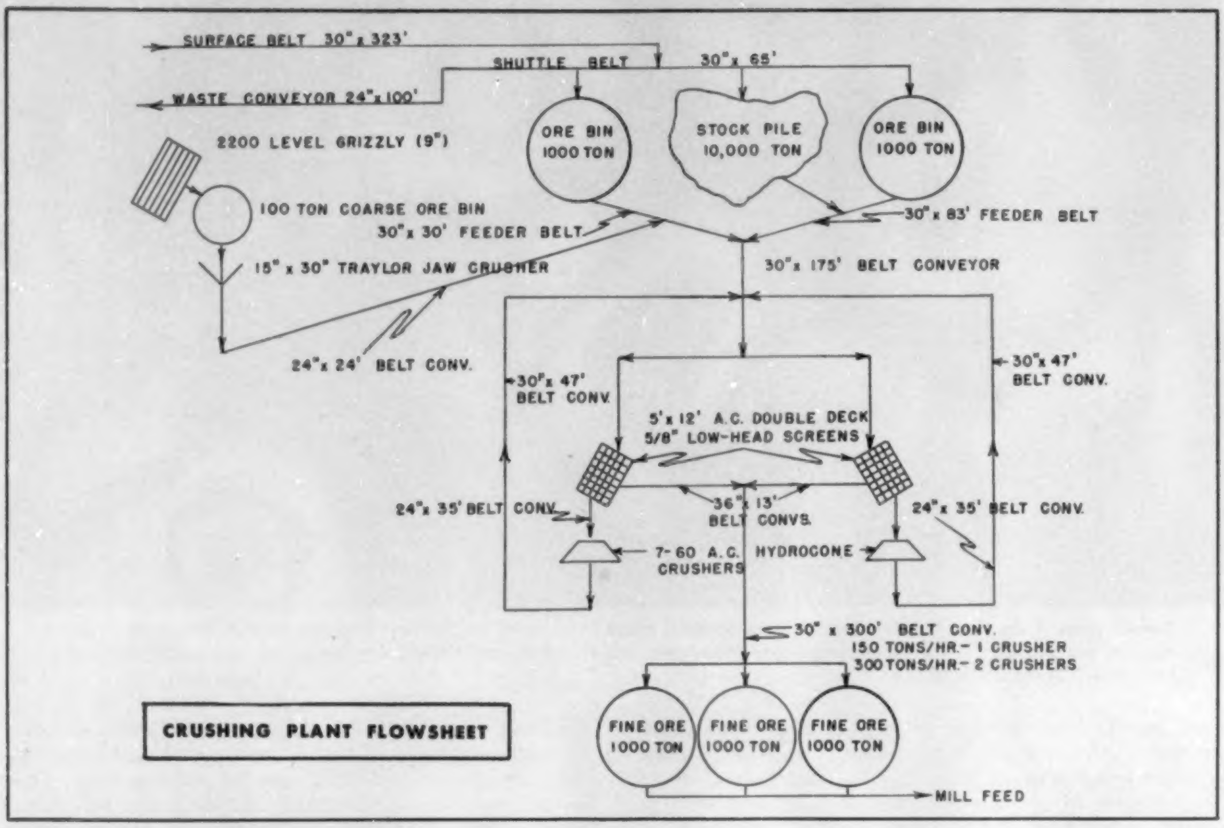
	Pct Retained					
Screen Mesh	48	65	100	150	200	—200
1938	6.4	10.3	10.5	11.0	10.1	51.7
Present	0.1	2.2	6.3	14.6	13.2	63.6

Flotation

The 56-in. Fagergren rougher cells are grouped in parallel banks of eight cells for the lead and ten cells for the zinc. Any lead bank can be used with

Table I. Crusher Product Sizing Analysis

Screen Retained, In.	Belt S-3 New Feed	Belt S-5 Hydrocone Feed	Belt S-6 Hydrocone Discharge
2	16.8	20.2	0.0
1½	13.0	8.4	0.0
1	14.7	11.5	1.5
¾	10.1	23.8	15.2
½	13.7	28.0	43.6
—½	31.7	8.1	39.7
Belt Load, tph	145.2	195.5	192.2



CRUSHING PLANT FLOWSHEET

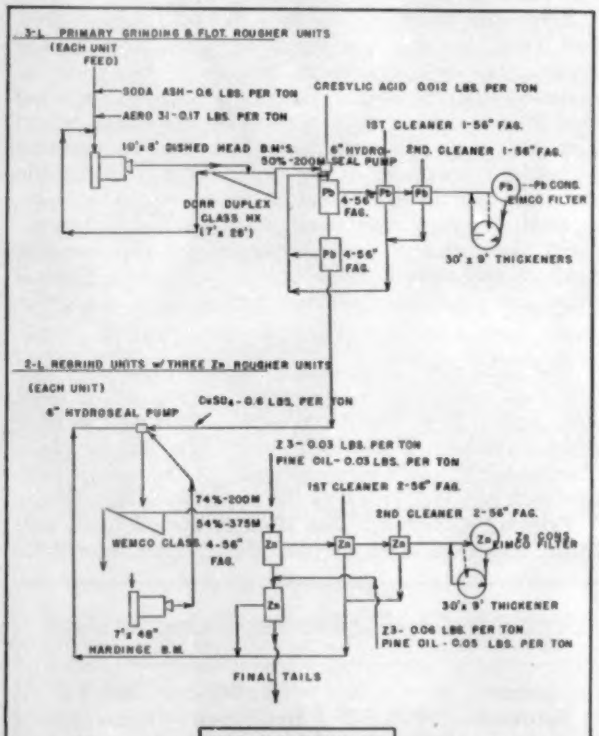
Table II. Ball and Liner Consumption

		Lb Per Ton
Balls:		
Primary mills	4 in.	2.19
Secondary mills	1½ in.	0.53
Liners:		
Primary mills		0.40
Secondary mills		0.02
Total		3.14

any primary mill and any combination of zinc cells can be run. Cleaner cells are the same type as the roughers but 6 in. deeper.

There is wide variation in feed to the mill, as the lead ratio of concentration may vary from 100:1 to 15:1 within an 8-hr shift, but operators are prepared to cope with these changes. The zinc does not vary as much, and with a large regrind circuit there is enough warning for compensation to take place.

It is characteristic of the ore that high grade concentrate can be made with high recovery, as a 72 pct lead grade can be maintained with about 1 pct lead reporting in the zinc concentrate. The zinc has virtually no floatability until activated by the cop-



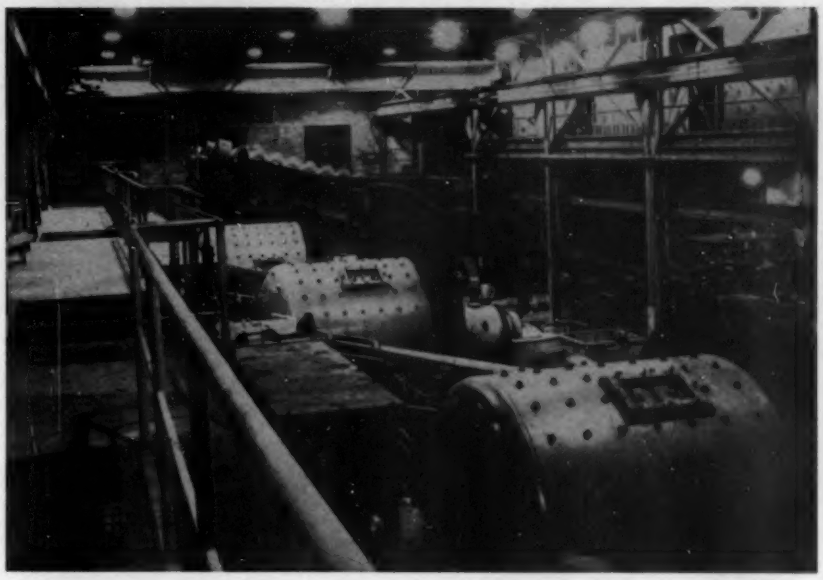
EAST MILL FLOWSHEET

Table III. Power Consumption Breakdown

	KW Per Ton
Primary crushing and conveying (underground)	0.757
Secondary crushing and conveying	2.376
Primary grinding	9.061
Secondary grinding	3.020
Flotation and auxiliary mill load	4.706
Total	19.920

per sulphate, and no zinc depressant is used in the lead float. Liquid copper sulphate is delivered to the mill by tank truck and airlifted to a lead-lined tank.

Graphitic carbon in certain of the lead sections responds to lignin sulphonates and is partly depressed. Addition of 0.025 lb per ton is sufficient, as amounts above this depress the lead. Best results



Ball mill bay of the East mill with 10x8-ft dished head Union Iron Works ball mills and 7x 28-ft DFX Dorr classifiers for the primary grind. In the background the regrind section is shown. Two 7x48-in. Hardinge mills with 60-in. Wemco classifiers regrind the lead float tails ahead of the zinc float.

are obtained by adding the reagent to the lead cleaners. Slime fractions in the zinc cleaner circuit are also depressed or dispersed by addition of 0.050 per ton, tests indicating 3 pct increase in grade and a slightly improved recovery. Screen analysis of the products is given in Table IV.

Filter bag life is lengthened by the addition of sulphonate, as bag consumption from blinding is cut nearly in half.

Operating Crew

There are 16 men on the operating crew. On each of the two shifts an operator and helper run the crushing plant, do the greasing and oiling, and make minor repairs. On the mill crew there are two men per shift on the basis of a three-shift, six-day week. As the work week is five days, a relief man fills in. The mill operators handle both grinding and flotation sections, and since circuits are large, changes normally occur slowly enough for corrections to be made.

The mill helper charges balls to the mills, handles reagents, and greases, spreading work over the three shifts as follows: day shift, reagents and ball mill floor equipment clean-up; afternoon shift, daily greasing and flotation cell cleaning; graveyard shift, general clean-up and pump and filter floor equipment.

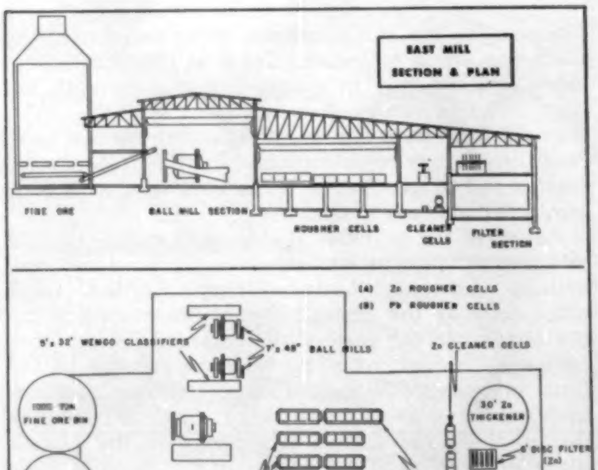
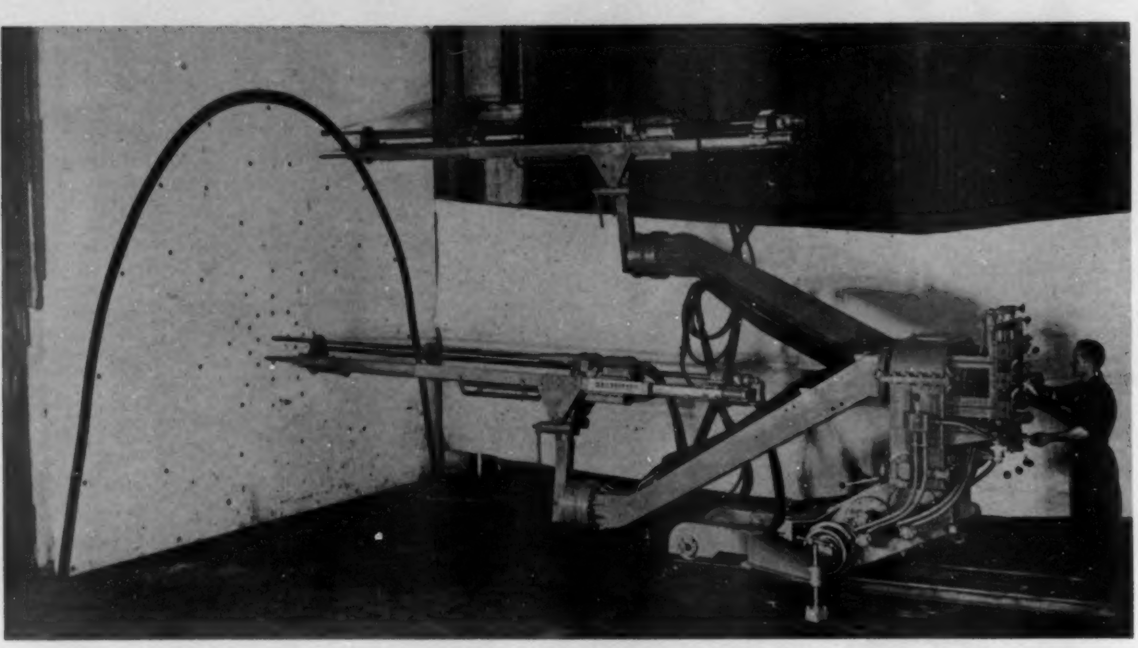


Table IV. Mill Products Screen Analysis

Screen	Ball Mill Feed Pct Retained	Ball Mill Feed Pct Total Pb	Ball Mill Feed Pct Total Zn	Ball Mill Discharge Pct Retained	Ball Mill Discharge Pct Total Pb	Ball Mill Discharge Pct Total Zn
½ in.	28.4	35.3	37.3			
4	38.9	6.4	38.0	4.8	1.0	5.4
10	16.1	15.8	10.3	7.0	1.0	7.8
28	6.1	10.9	3.7	21.2	1.0	14.9
35	1.2	2.6	0.7	12.5	1.7	7.4
48	1.2	3.1	0.9	10.9	3.2	8.4
65	1.1	3.2	0.9	8.6	8.1	9.3
100	0.9	2.9	0.9	5.0	7.9	5.9
150	1.0	3.5	1.1	5.3	10.8	6.7
200	0.7	2.6	0.9	3.8	8.2	5.3
−200	4.4	13.7	5.3	20.9	57.1	28.9
	Primary Classifier Sand			Primary Classifier Overflow		
4	9.7		4.1			
10	13.6		14.5			
28	31.3		23.8			
35	15.4	0.6	11.7	0.8		0.3
48	10.4	8.3	10.7	6.5		1.7
65	5.2	17.0	8.9	12.0		4.7
100	2.8	14.5	5.6	10.5		6.5
150	2.4	18.0	4.6	12.1	3.2	11.8
200	1.7	11.4	3.0	3.0	3.8	3.7
−200	7.9	30.2	13.1	55.1	93.0	71.3
	Lead Circuit Tails			Regrind Mill Discharge		
35	1.6	100	0.6	0.9		0.6
48	11.5		4.4	2.8		0.5
65	13.7		6.8	20.2		7.0
100	10.1		7.6	21.5		13.3
150	11.3		11.7	18.1		25.0
200	8.4		10.6	9.2		16.9
−200	43.4		58.3	27.3		37.2
	Regrind Classifier Sand			Regrind Classifier Overflow		
35	3.7		0.0			
48	15.5		1.3	0.1		—
65	30.4		2.6	2.2		0.6
100	23.6		16.7	6.3		1.6
150	12.8		34.3	14.6		6.7
200	4.1		17.3	13.2		10.4
325	9.9 (−200)		26.9	14.4		15.1
−325				49.2		65.6

The repair crew consists of a mechanic and two repairmen. All three are good welders and general handy men. When the ball mill or crusher is relined the repair crew is augmented by men drawn from the surface crew and elsewhere.

In the assay office two men do all assaying of mill control samples, smelter shipments and control, and screen sizing analysis.



Jumbo equipped with two Salzgitter rotary percussion drills is reported to give excellent service in drift headings of the Ruhr district. The unit is controlled by one man operating the panel on the back of the jumbo.

Rotary Percussion Blasthole Machine May Revolutionize Drilling

by W. D. Lacabanne and E. P. Pfleider

Rotary percussion drilling is a combination of the advantages of two standard methods to produce maximum penetration rates in hard rock. Post-war needs in European mines for lower production costs led to the development of this machine.

ROTARY percussive drilling, vibro-drilling, vibro-rotation drilling, rotary pulsating drilling—all names that mean the same thing—are gradually appearing in mining literature. What is rotary percussive drilling? It is a combined system superimposing a rapid percussive impact on a continuous rotary action in an attempt to utilize the most desirable features of both methods.

At present single and multiple carriage-mounted rotary percussion units are being used in the European coal mining regions. One well engineered unit is the Hausherr "Albo" rotary percussive drill, utilizing two alternately operating percussion pistons, and another is the multiple-unit, jumbo-mounted Salzgitter machine. Nüsse & Gräfer also manufacture rotary percussion drills.

The post-war need for greater speed in hard rock penetration led to the development of rotary percussive drilling in Europe, particularly in Germany. Although the idea was conceived in Great Britain as early as 1922, only in the last few years has it developed to the point where commercial drilling machines are in operation. Jahn[1] at Clausthal, Germany, led the way in an attempt to cope with the hard rocks encountered in drifts of the Ruhr region. Patzold[2] of France and Inett[3] of Great Britain have made important contributions. In the U. S. several small hand tools rotating up to 1000 rpm with 6000 blows per min are available.

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Action of the percussion-type drill makes it most effective in hard rock; however, it produces low drilling efficiency because fragmentation takes place only at the instant the hammer strikes the rod shank. In the case of the rotary drill, a higher efficiency is realized. The bit cuts 100 pct of the time, but its use is limited because thrust requirements become excessive in hard rock. A combination of these two actions capitalizes on the advantages of each drill, rapidly cutting through high strength rocks with less energy or thrust than occurs with either method individually. The instantaneous impact of percussion cuts grooves into the rock, while the constant high thrust rotary movement shears off the intergroove ridges.

This performance is explained by the fact that high thrust and torque create stresses of rotation

Advantages of Rotary Percussion Drilling

1) Better performance. One Hausherr carriage-mounted unit replaced five air-leg percussion drills, achieving a five-fold increase in drilling speed with less manpower and with the same quantities of air and water.

2) Longer bit life in harder rocks.

3) Constant thrust on drill steel, reducing vibration and thus increasing rod life.

4) Coarse size of cuttings, showing higher drilling efficiencies and lower dust hazards.

Principal Characteristics of Rotary Percussion Drilling Machines (after Patzold)

Compressed air pressure	45 to 120 psi
Power of motors (2 motors)	5.6 to 10 hp
Thrust	1300 to 2600 lb
Frequency of percussion	1000 to 3000 per min
Speed of rotation	50 to 250 rpm
Speed of penetration	1 to 4 fpm
Power of impact per blow	11 to 30 ft-lb
Rate of advance	15 fpm
Number of blows per revolution of bit	20 to 120
Distance of advance (max)	8 to 11 ft
Weight of machine	8000 lb

at intensities approaching the rock's competent strength, combining with a high percussive impact on the prestressed rock to snap off large fragments. During the period between percussive blows, the rotary action shears away the rock ridges and leaves the bottom of the hole essentially smooth.

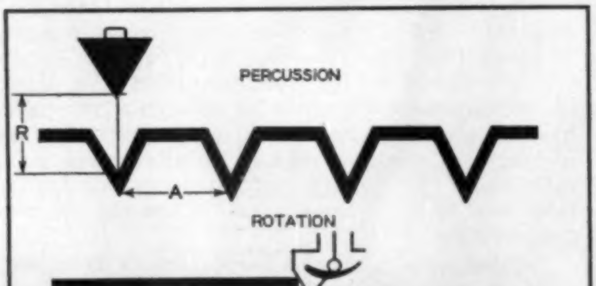
The number of percussive blows and revolutions must be interrelated to obtain good cutting action and smooth bottom. Indexing must be determined for each rock type. The percussion rate should increase with revolutions, particularly in larger diameter holes, because at the hole periphery the distance between grooves or ridges is greater and the free face is farther away.

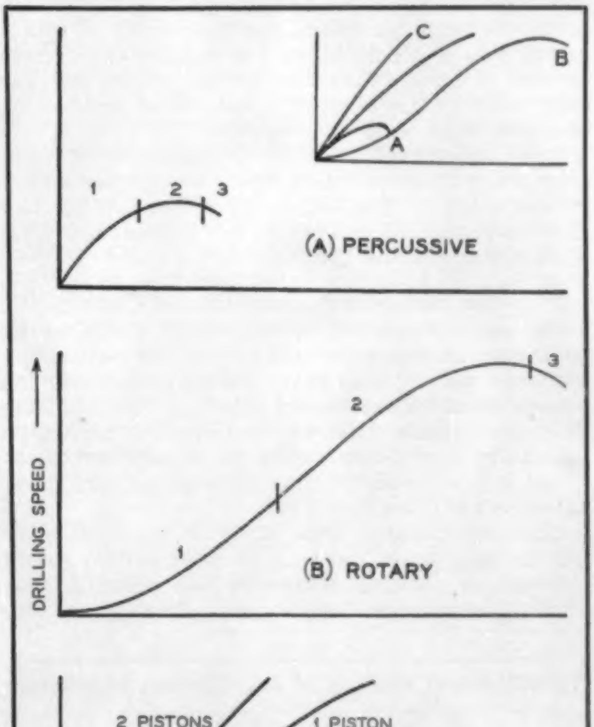
With rotary percussion action the number of blows per minute should be reduced as the revolutions decrease to maintain efficient indexing. Under these conditions drilling produces larger fragments and less pulverizing. However, as rotary motion is slowed, percussive force should be increased. If machines have but one valve that controls air to both the rotary and percussion actions, the force of the blow will be decreased when the machine operates at slower speed. To adapt rotary percussive drilling to the hardness of rock the drill should be equipped with power plants, controlled independently to regulate rotation and the frequency and intensity of blows.

The best rotation rates for rocks of different hardnesses vary up to 250 rpm, frequency of percussive blows may be from 2000 to 3000 per min, and power of blows between 11 to 30 ft-lb. Under these conditions, Inett[8] reports drilling speeds up to 35 in. per min for granite, 47 in. for hard sandstone, 67 in. for medium hard sandstone, and 86 in. per min for sandy shale.

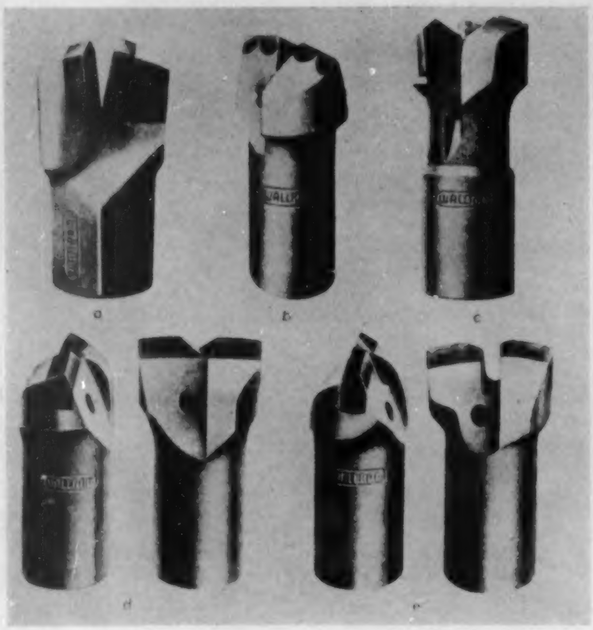
Bit Designs Critical

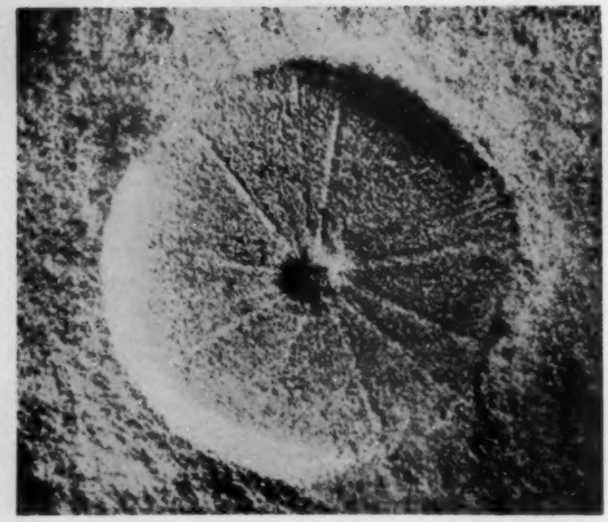
Rotary percussive drilling requires bit designs with the cutting clearance space of rotary bits and the impact strength of percussion bits. Principal features of the rotary percussion bit are the leading





RIGHT—Comparisons of drilling speed vs applied thrust of the three drilling systems. Curves given for percussion and rotary drilling are divided into three parts: 1) initial stage of low thrust; 2) balance of all factors; and 3) stalling produced by high thrust. Small graph in upper right is a combination of the three individual plots. (After Inett.) ABOVE—Characteristic cutting action of the three drilling systems: grooving for percussion, scraping for rotary, and a combination of impact and shear for rotary percussion. (After Patzold.)





LEFT—Many designs of rotary percussive bits are used in the Ruhr. Five types are shown. (After Jahn.) ABOVE—Bottom of a rotary percussive drillhole showing smooth rock surface almost without grooves or ridges. (After Patzold.)

angle and greater strength of cutting edges, since components of the vertical impact and horizontal shearing forces combine to give a periodic resultant at some angle to the bottom of the hole. Inett[3] reports bit angles of 80° compared to 107° to 110° for percussive drills. Patzold[2] shows about the same angle, and Jahn[1] gives 70° to 80°.

Generally, optimum drilling speed is that which gives the least bit wear. The superiority of rotary percussion in terms of bit life and footage of hole drilled is clearly indicated in the graphs on page 853; after 35 min of drilling the rate of penetration is higher than with other methods.

Inett reports bit life for rotary alone as 10 ft per regrind, with about ten regrinds possible for a total of some 100 ft. For rotary percussive bits 25 ft of hole per regrind is considered normal and total drilled hole is about 250 ft.

Rotary Percussion Produces Coarser Cuttings

Screen analyses of rock cuttings produced by rotary percussion drilling shows higher percentages of large size cuttings than obtained by percussion alone. Patzold's results are shown in Table I. Note that the largest diameter cuttings for percussion alone are 1 to 2 mm, while for rotary percussion there is a wide distribution of large cuttings up to diameters of more than 5 mm.

The percentage of fines, of −0.75 mm, is 81 to 90 pct for percussion and only 38 to 61 pct for rotary percussion, showing that with the latter drilling method better rock fragmentation takes place. According to Rittinger's law of comminution, and drilling results reported by Hartman and Pfleider,[4] energy requirements vary inversely as particle size produced to the 3.3 power. Thus under equal drilling conditions percussion alone requires more energy to fragment rock. Most of the energy is used in pulverizing the rock and regrinding cuttings, while in rotary percussion the same energy produces fewer, but larger rock fragments.

It is important to note that the smaller percentage of fines in rotary percussion drilling reduces rock dust hazards.

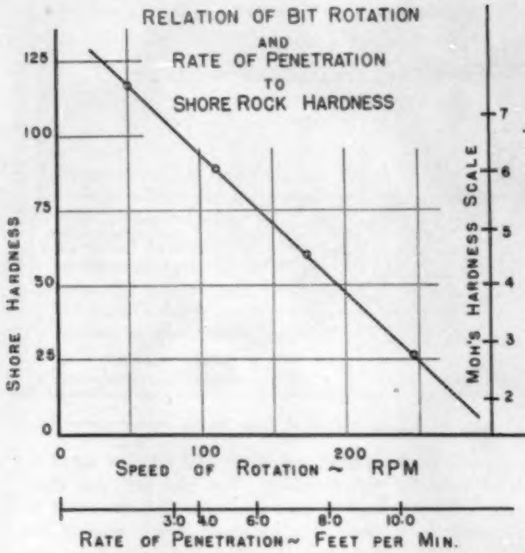
U. S. Research and Development

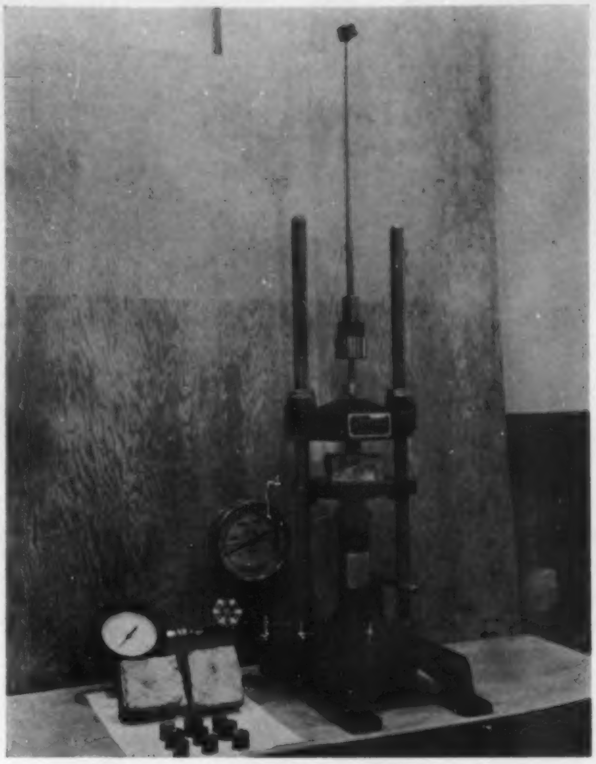
Battelle Institute has studied the application of rotary percussion methods to oil well drilling for several years. The primary problem is to get sufficient energy to the bottom of a 10-in. hole 10,000 ft deep. A full-scale working tool was constructed to drill a 10-in. hole with percussion action of about 1000 blows per sec superimposed on the rotary action. The high frequency percussion action of low amplitude was obtained through a transducer by means of magnetostriction or the small change of length of a nickel tube in an alternating magnetic field. Preliminary performances gave drilling rates two to three times greater than the conventional rotary.

Kemler[5] reports various developments in oil well drilling using mechanical and hydraulic attachments to produce percussion action. Weights of 120

Table I. Screen Analyses of Drill Cuttings from Rotary Percussion Drilling and Percussion Drilling. (After Patzold[2])

Shore Hardness	Pressure Compressed Air, Psi	Hammer	Grain (Cutting) Size, Mm						
			+5	4 to 5	3 to 4	2 to 3	1 to 2	0.75 to 1	−0.75
70	73	AZ20	—	—	—	—	4.0	8.0	88.0
		Rotary-Per. A	3.3	5.0	6.7	7.6	15.0	4.3	58.1
		Rotary-Per. B	4.5	8.0	9.2	9.5	16.2	3.8	48.8
	110	AZ20	—	—	—	—	2.5	7.5	90.0
70 to 86	80-110	Vibro	3.9	7.4	8.7	11.0	21.8	9.2	38.0
100	70-73	AZ20	—	—	—	—	8.0	10.5	81.5
		Rotary-Per. B	—	4.5	—	6.5	20.5	7.0	61.5





ABOVE—Proper coordination of the speed of rotation, number of blows per minute, and force of impact is necessary to obtain the best drilling results with the rotary percussion machine. This plot indicates that depending upon the rock hardness, the rotation can vary from 50 to 250 rpm. RIGHT—Rock samples are pre-stressed under a single tungsten carbide insert with a hydraulic press, then under an impact stress superimposed with a falling weight.

lb have been moved at rates up to 2000 blows per min and with strokes up to 1⅜ in.

In laboratory tests reported by Kemler, a fluid-actuated rotary percussion engine drills four to ten times faster than the straight rotary. The ratio of rotary percussive drilling rate to conventional drilling rate as related to various thrusts shows the advantages of rotary percussion drilling at moderate to low bit loads. This characteristic is important in crooked hole drilling where low thrusts are required.

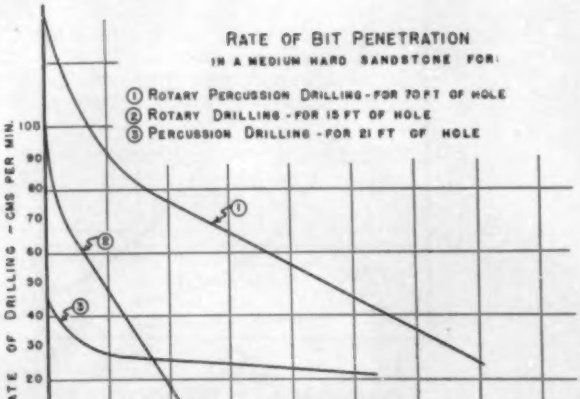
A few manufacturers, including the Hughes Tool Co., are working on improvements of rotary percussion drills. Several manufacturers are marketing a number of hand drills for holes from 3/16-in. to 1½-in., 40 ft deep. One tool, weighing less than 10 lb, rotates at 1000 rpm and strikes 6000 blows per min.

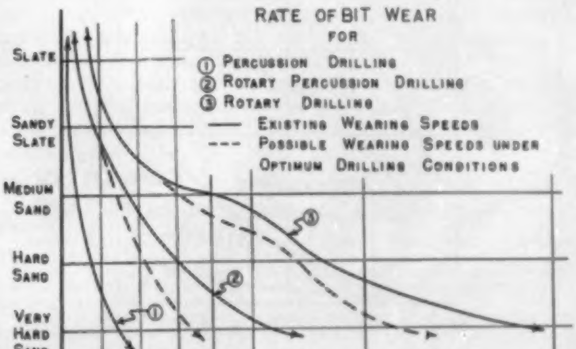
Rotary Percussive Research at Minnesota

Research work in diamond, rotary, and percussion drilling has been in progress for several years at the School of Mines and Metallurgy, University of Minnesota. These studies have directed Minnesota research into the new field of the combination rotary-percussive methods. Fundamental research on the failure of rocks through combined static and impact loading is now in progress.

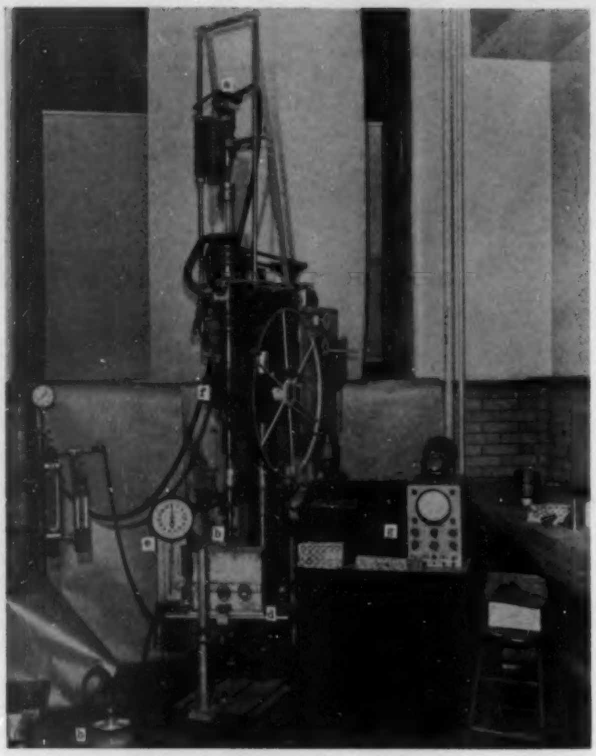
A simple laboratory hydraulic press is used to create the high static stresses and drop weights to produce varying impact stresses. The small craters formed in the rock surface around the tungsten carbide cutting element are measured, and this information is related to the combinations of loadings. The data may lead to a better understanding of rock fragmentation.

Experiments are also being initiated in a dynamic rotating system simulating the actual rotary-percussive drills. A drill press with an air hammer



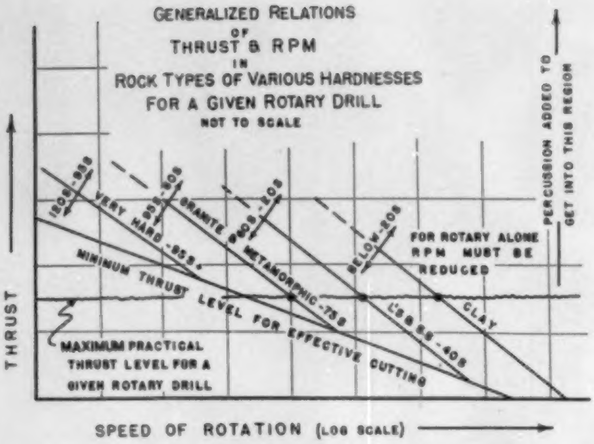


Curves comparing wearing rate of drill bits for the three methods of drilling. It is shown that the rotary percussive system gives longer bit life than either rotary or percussion. (After John.)



Rotary percussive laboratory drill for test work at the University of Minnesota. Key: a) air hammer, 2100 blows per min at 10 ft-lb; b) drill bit, 1 in. diam; c) lead weights for constant drill thrust—not shown; d) torque table and sample holder; e) free floating to measure torque; f) instantaneous drill rate recorder; g) strain gage recording equipment; and h) cuttings receiver.

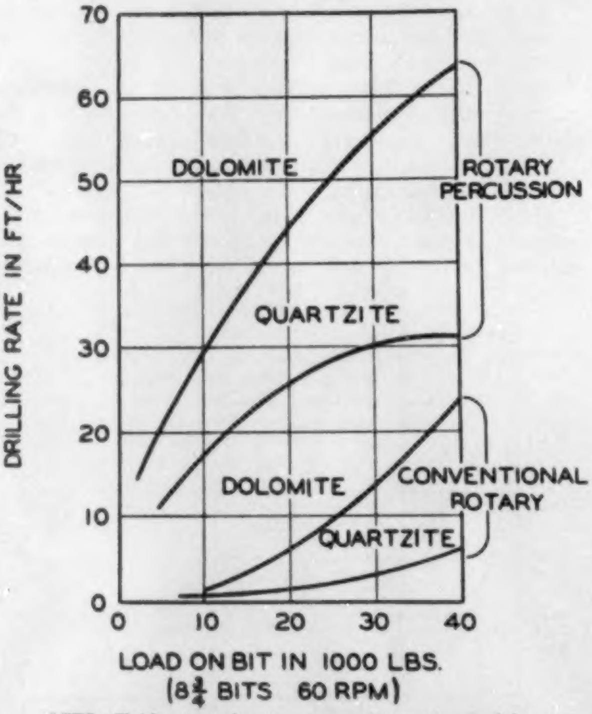
unit has been adapted for this purpose. Instrumentation permits the recording of thrust, torque, water flow, rpm, and near-instantaneous drilling

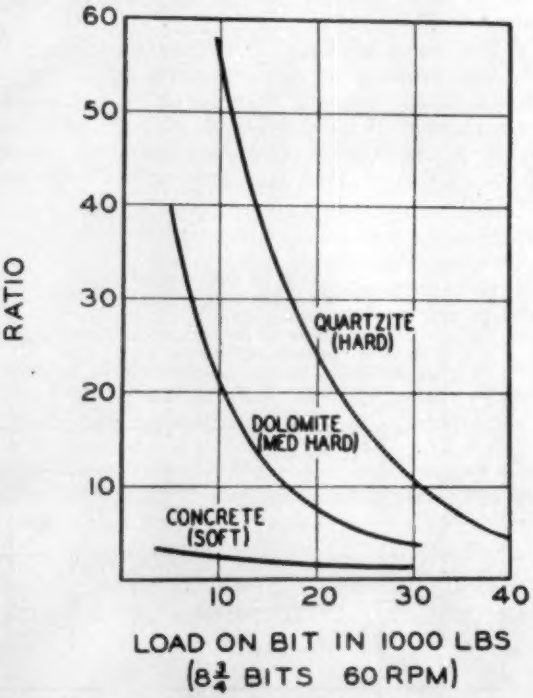


Generalized graph relating rod thrust and rotation speed to rock hardness for rotary drilling. The plot indicates that: 1) rotation speed must be lowered as thrust is increased to avoid stalling; 2) there is a minimum thrust required for effective cutting rates; and 3) rotary percussive drills can overcome the thrust deficiency to make them effective in harder rocks.

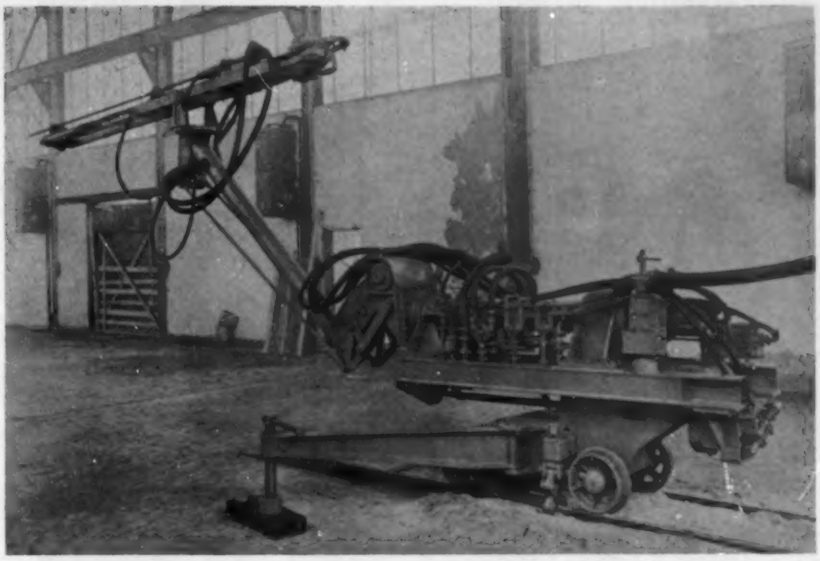
rate. The drill cuttings are collected for sizing analyses, and both the static and dynamic loadings on the bit are measured with Baldwin SR-4 strain gages and a Baldwin-Sanford recorder or an oscilloscope. Drilling conditions may be varied easily and all basic factors recorded and studied for runs as short as 1 to 4 in. deep.

A short study has been completed on the possible application of percussive blows to a rotating diamond bit. The tests showed: 1) that breakage and wear of diamonds in the bit were excessive; 2) that an equal increase could be achieved more simply by addition of rotary energy; and 3) that an increase in drilling rate was obtained with the addition of percussive energy.





LEFT—Fluid-actuated rotary percussion engine in laboratory tests is reported to show a 4 to 10-fold advantage in drilling rates over the straight rotary drill. RIGHT—Graph gives comparison of ratio of drilling speeds of rotary percussive and straight rotary with bit load. Ordinate on plot is drilling speed ratio. At a low thrust of 10,000 lb the rotary percussive drills 20 times as fast in dolomite as the rotary. This low thrust characteristic is important in crooked hole drilling. (After Kemler).



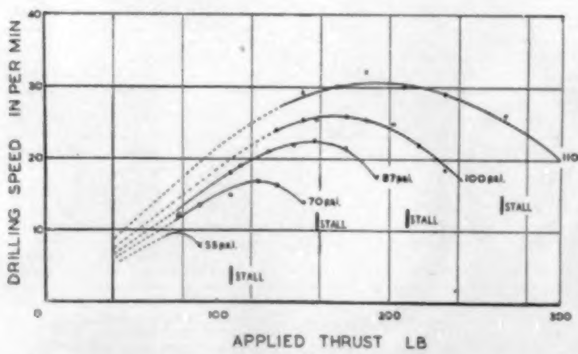
Many years of development work have been put into the rotary percussive drill used in Europe. A need for faster penetration in headings stimulated the research and now the machine is being produced by several manufacturers. Shown is a single arm jumbo with a Salzgitter rotary percussion drill.

Principles of Percussion and Rotary Drilling

Percussion Drilling—Actual fragmentation with percussion tools takes place for a small portion of total in-hole drilling time, possibly as low as 2 to 5 pct. Because the necessary rotation of the drill steel is integral with piston travel, indexing takes place during the up or down stroke of the piston. No breakage occurs during this part of the cycle. Rock characteristics markedly affect the amount of indexing required for efficient fragmentation, but in actual practice, optimum conditions are seldom obtained. Although changing rifle bars in the drill can control rotation there is either over-indexing so that the free face of the previous groove is too far away to break out a good chip, or the reverse occurs and the rock is merely pulverized.

Overtravel or free rotation of the drill steel during indexing also gives poor fragmentation. Increased thrust on the cutting tool reduces free rotation, but the greater bit pressure increases the torque required for indexing. More of the piston energy must then be diverted to rod rotation and eventually the drill stalls. Rig-mounted percussive drills reach their maximum penetration rates with 200 to 300 lb of thrust.

During the power stroke in percussive drilling, the bit cutting edges are forced against the rock. At the points of highest stresses—under the cutting edges—some of the rock is fragmented, but the rest of the rock, through its elasticity, is compressed and surcharged with potential energy transmitted by the action of the tools. On the upstroke of the piston this potential energy is dissipated through the rebound of the tools or as heat. Thus only a small part of the drilling energy is actually utilized in breaking rock. Unless conditions are favorable, fine cuttings having a large surface area are formed and produce low rates of advance.



Relationship of drilling speed and applied thrust at different air pressures for percussion drill.

Despite the disadvantages of percussive drilling, the principle is still considered essential in drilling hard rock, because of the instantaneous delivery of the high impact stresses required at the bit.

Rotary Drilling—Fragmentation of rock by rotary drilling takes place by a scraping or shearing action. To produce a chip the cutting edges of the bit must be forced into the rock while the bit rotates. Thus to produce larger cuttings and higher penetration rates, more thrust is necessary to force the bit cutting edges deeper into the rock. If adequate thrust is not maintained the bit does not penetrate the rock but rather scrapes along the surface, producing a fine rock powder. Under these circumstances advance is slow and bit wear excessive.

For soft rock, moderate thrusts easily provided by the drilling machine keep the bit deep in the rock to produce large cuttings for a high rate of bit advance. For progressively harder rocks the higher thrust forces require massive machines.

In the rotary drill, as in the percussive, the applied thrust ultimately governs the speed and range of a given machine. Greater thrusts cause the bit to turn harder and eventually stall. Thrust values for rotary machines may be as high as 3000 lb—about ten times that of percussion drills—to assure maximum penetration speeds.

For a machine of given horsepower, as the thrust and torque is increased in the harder rocks the bit revolution must be decreased to prevent stalling. Of greater importance, the rotation must be decreased to avoid a planing action of the bit, where the up-component of the force resisting rotation tends to make the bit-inserts ride over the rock surface. Patzold's studies show that as hardness of the rock increases, the optimum revolution of the bit decreases in a straight line relationship.

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INTERNATIONAL MINERAL TRADE SERIES

Part VI

World Trade in Lead Metal and Concentrates

by John D. Ridge and Robert C. Barwick

THE amount of lead in concentrates that moved in international trade in 1952 was only 16 pct of the world mine production of lead and was less than 27 pct of the total of lead in concentrates and lead metal that traveled from one country to another. Because almost all lead is derived from galena, lead concentrates are high grade, with a theoretical maximum of 86 pct lead, and can be shipped as such without transporting a considerable weight of waste material. It would not be surprising, therefore, to find the large share of lead in international trade moves in concentrates (Rule 5). This is not, as has just been mentioned, actually the case. There is more than one explanation for the situation. Lead smelting is not a particularly difficult process and is one for which smelting equipment can readily be made of the best size for the tonnage to be handled. Another factor that encourages local smelting is the effort of many mining countries to see that a maximum of profit from their raw materials remains in the home country. Still another factor is the newness of large scale lead mining in two of the three largest exporters of lead in concentrates. In these countries, South West Africa and French Morocco, there has not yet been time to erect enough smelting capacity to process all of the concentrate output. Even in these countries, however, it will not be long, if present trends continue and plans are fulfilled, before most or all of the lead mined is domestically smelted. In 1950 French Morocco reported no lead smelting at all, but in 1952 nearly 40 pct of lead mine production was smelted in that country. To a very considerable extent then, three rules (3, 5, and 7), taken one alone or two or more in combination, account for the concentration of lead smelting in mining countries.

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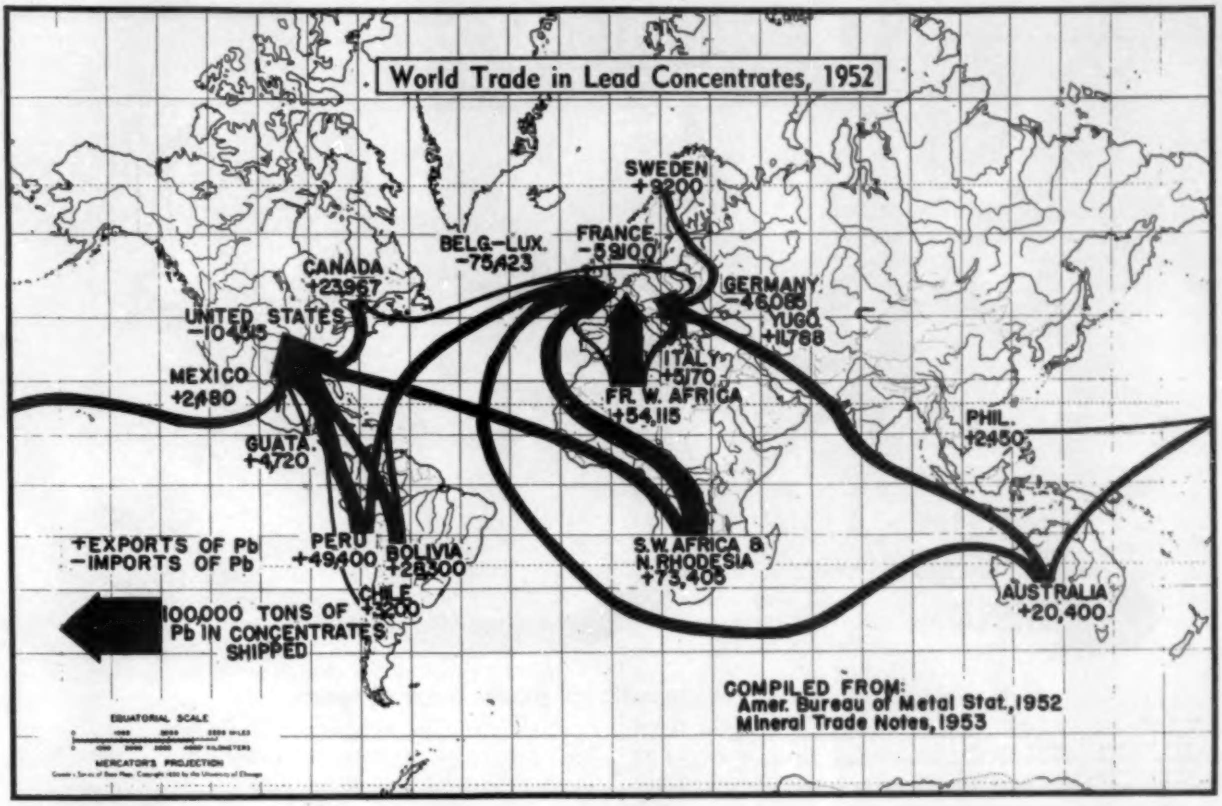
The four largest exporters of lead in concentrates (see Table VIII) are countries of little industrial activity. For two of these, the relatively low percentage of lead smelted domestically has been explained by the newness of the local lead mining operations. In the other two countries, while lead production has greatly increased since World War II, lead smelting has not. In Peru there has been little incentive for building new smelters when smelters in the U.S. and Europe are willing to pay well for

Table VIII. World Trade in Lead Concentrates,* Tons, 1952

		Importer							
Exporter	Total	U. S.	Belg.-Lux.	France	Germany	Tunisia	U. of S.A.	Misc.	Europe
S. W. Africa	61,403	25,875	33,146	—	—	—	—	2,500	(33,146)
Fr. Morocco	48,465	—	6,930	34,630	1,200	4,400	—	2,000	(42,760
Peru	49,400	28,210	21,200	—	—	—	—	—	(21,200)
Bolivia	28,300	18,473	9,800	—	—	—	—	—	(9,800)
Canada	23,967	11,937	8,000	—	4,000	—	—	—	(12,000)
Australia	20,400	8,932	9,470	—	—	—	—	2,000	(9,470)
N. Rhodesia	12,002	—	2,240	—	—	—	7,950**	2,000	(2,240)
Yugoslavia	11,788	—	—	—	11,788	—	—	—	(11,788)
Sweden	9,200	—	—	—	9,200***	—	—	—	(9,200)
Italy	5,170	—	—	—	5,170	—	—	—	(5,170)
Guatemala	4,720	4,720	—	—	—	—	—	—	—
Fr. Eq. Africa	3,350	—	—	3,350	—	—	—	—	(3,350)
Chile	3,200	3,200	—	—	—	—	—	—	—
Mexico	2,487	2,487	—	—	—	—	—	—	—
Philippines	2,446	2,446	—	—	—	—	—	—	—
Algeria	2,300	—	—	—	—	2,300	—	—	(2,300)
Africa	(127,520)	(25,875)	(42,316)	(37,980)	(1,200)	(6,700)	(7,950)	(2,000)	(81,469)
S. America	(80,900)	(49,883)	(31,000)	—	—	—	—	—	(31,000)
Europe	(26,158)	—	—	—	(26,158)	—	—	—	(26,158)
	288,598	106,280	90,786	37,980	31,358	6,700	7,950	9,500	(162,424)
				1932					
Canada	34,000	12,000							22,000
S. America	7,000	2,000							5,000
Africa	6,000	—							6,000
Europe	5,000	5,000							—
Australia	4,000	—							4,000
India	4,000	—							4,000
	60,000	19,000							39,000

U. S. Production 1952 — 390,162.
* Includes ore and concentrates.
** Probably largely shipped out of Africa.
*** Perhaps 35 pct of these concentrates went to Belg.-Lux.



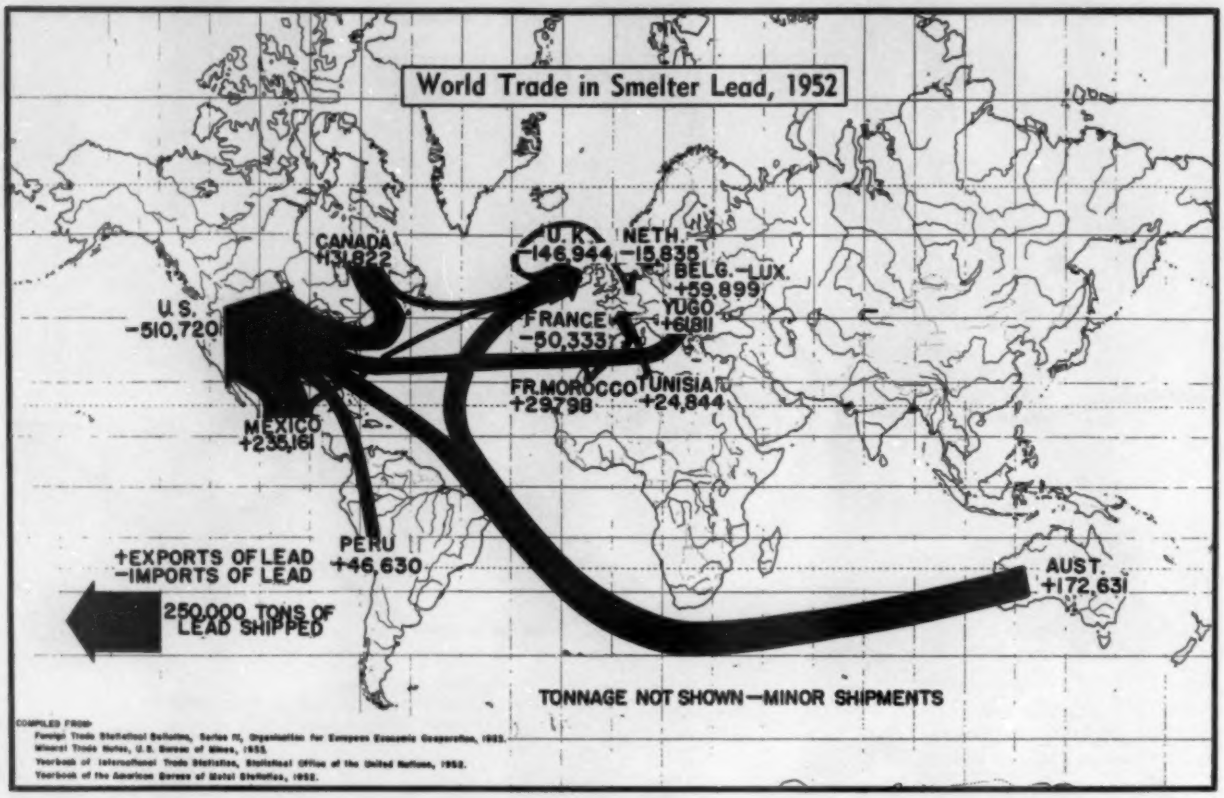
lead concentrates. This is true for Bolivia as well, where the political climate is an added deterrent to further investment.

In 1952, the U. S. was the largest importer of lead in concentrates (see Table VIII), with Belgium-Luxemburg not far behind with slightly over 90,000 tons. France and Germany were the two importers of moderate size with somewhat over 30,000 tons each and there were no others of real importance. The U. S. gets its lead in concentrates from all over the world. Peru, South West Africa, and Bolivia were the largest suppliers in 1952 and in all, nine countries provided the U. S. with over 2,400 tons each in that year. Belgium-Luxemburg obtained the largest share of its lead in this form from South West Africa, a considerable amount from Peru and smaller quantities (but above 2,000 tons each) from five other countries. France depended for its

Table IX. World Trade in Lead Metal,* Tons, 1952

		Importer								
Exporter	Total†	U. S.	U. K.	France	Netherlands	Denmark	Sweden	Germany	Misc.	Europe
Mexico	235,161	198,872	22,200	3,068	—	—	—	—	12,000	(25,068)
Australia	172,631	82,800	81,247	—	—	—	—	—	8,500	(81,247)
Canada	131,822	104,531	25,174	—	—	—	—	—	6,000	(25,174)
Yugoslavia	61,811	53,564	—	—	—	—	—	3,155	5,000	(3,155)
Belg.-Lux.	59,899	—	8,062**	3,000	15,835	7,050	5,118	—	20,000	(33,947)
Peru	46,630	42,169	4,500	—	—	—	—	—	—	(4,500)
Fr. Morocco	29,798	6,051	—	23,068	—	—	—	—	—	(23,068)
Tunisia	24,844	—	—	18,287	—	—	—	—	6,000***	(22,500)
Europe	(121,710)	(53,564)	(8,062)	(3,000)	(15,835)	(7,050)	(5,118)	(3,155)	(25,000)	(42,220)
Africa	(48,085)	(6,051)	—	(41,355)	—	—	—	—	—	(41,355)
	(762,596)	510,720	146,944	50,333	15,835	7,050	7,000	3,155	57,500	(218,659)
				1932						
			Japan	Europe	Russia	Asia	Africa			
Canada	99,000	—	25,000	67,000	—	3,000	—			
Mexico	96,000	12,000	1,000	79,000	4,000	—	—			
Australia	175,000	—	—	171,000	—	2,000	—			
Europe	39,000	—	—	—	30,000	—	6,000			
Africa	12,000	—	—	12,000	—	—	—			
India	61,000	—	11,000	49,000	—	1,000	—			
U. S.	21,000	—	18,000	2,000	—	—	—			
	503,000	12,000	57,000	380,000	34,000	6,000	6,000			

U. S. Production 1952 — 383,358.
* Includes pigs and bars.
** Plus 6,000 tons transit trade.
*** 2,000 tons each to Switzerland, Italy, Algeria.
† Importer totals may also include tonnages from minor exporters not large enough to appear individually. Totals of vertical columns, therefore, may also be larger than the sum of their listed parts.



supplies on French Africa, mainly French Morocco, while Germany obtained its imports principally from Yugoslavia, Sweden, and Italy.

In 1952, 16 countries exported over 2,300 tons of lead in concentrates. The largest amount, 61,403 tons, came from South West Africa; about 50,000 tons each came from French Morocco and Peru; 20,000 or more from each of Bolivia, Canada, and Australia; and over 10,000 each from Northern Rhodesia and Yugoslavia. If the Philippines are considered to be an Asiatic country, then all five continents are represented in the list of lead concentrate exporters, but none of them is a major industrial nation, although Canada, Australia, Italy, and Sweden are well up in the second rank industrially.

As has already been pointed out, the bulk of the world's trade in lead is carried out in largely or completely refined lead. Only eight countries were important exporters of lead in 1952, with over 70 pct of the total traded coming from Mexico, Australia, and Canada (see Table IX). Of the more than 750,000 tons of lead exported, slightly over two-thirds came to the U. S. and nearly 95 pct went to three countries, the U. S., the United Kingdom, and France. The U. S. derived its imports from Mexico, Canada, and Australia in that order, followed by less important amounts from Yugoslavia and Peru. The U. K. got most of its lead from Australia, with smaller and about equal amounts from Canada and Mexico and minor amounts from Belgium-Luxemburg and Peru. France obtained lead mainly from French North Africa, French Morocco, and Tunisia, and considerably lesser amounts from Mexico and Belgium-Luxemburg. Belgium-Luxemburg was the main supplier of countries needing relatively small amounts of lead, sending appreciable tonnages to the United Kingdom, France, the Netherlands, Denmark, and Sweden and minor amounts to Switzerland, Brazil, and several other countries. The larger exporters have fewer large customers: Mexico, Australia, Canada, and Peru have the U. S. and the United Kingdom, while Yugoslavia has the U. S., and French North Africa has France.

Of copper, lead, and zinc—the three principal nonferrous metals—lead is the only one of which the U. S. produces less from domestic ores than it imports in foreign concentrates and as foreign lead. This position is less serious that it looks at first glance for three reasons. The first of these is that U. S. production of secondary lead is equal to that obtained from domestic and foreign concentrates, so that imports of foreign lead amount to only 35 pct of the total made available to the U. S. in 1952. Secondly, U. S. consumption in 1952 was less than U. S. total supplies for that year by some 337,000 tons. The third reason is the close spatial relation of the U. S. to its two main suppliers, Mexico and Canada. Lead imports from these sources could be seriously interrupted only by actual land invasion.

The International Mineral Trade Series—

In this issue MINING ENGINEERING presents the sixth of a continuing series of articles on movement between nations of the vital minerals, the essential metal raw materials. Part I and Part II appeared in May, Part III and Part IV in June, and Part V in the July issue.

Additional articles in the series to appear in forthcoming issues include those on zinc, tin, mercury, bauxite, and aluminum.

REPRINTS: No requests for reprints will be filled until the completion of the series. At that time an announcement will be made in MINING ENGINEERING as to availability of the complete series of articles.

Cage to Hoisting Engineer — Emergency Communication

by W. A. Boyer and A. W. Beck

AT the Morning mine of American Smelting & Refining Co. it was particularly important that there be a means of signaling the engineer from the moving cage in the shaft. Because of the shifting ground in which the shaft was located, buckling timber made it extremely difficult to keep a continuous bell line serviceable.

In 1930 engineers considered a moving contact pantograph arrangement between the cage and two stationary messenger wires strung on insulators in the shaft compartment next to the cage. The idea was abandoned because falling material in the shaft and speed of hoisting made it difficult to maintain communication. Later in 1934 a manufacturing company was consulted about the use of an electric eye or a radio signal. As the shaft was located in a return air stream of nearly 100 pct relative humidity, there was too much fog for the electric eye to be used. The radio signal was considered, and it was believed feasible to generate electric static on the cage, locating a radio receiver at the top of the shaft, but the manufacturing company's research department was too busy to work on it at that time.

Shortly after this it was learned that L. D. Stewart of Ironwood, Mich., had developed the Sigaphone, which worked on exactly the principle mentioned above, the transmitter consisting of a spark coil and the receiver of a simple untuned radio frequency amplifier. A complete unit procured in 1938 was used for several years, but moisture in the shaft hindered consistent operation.

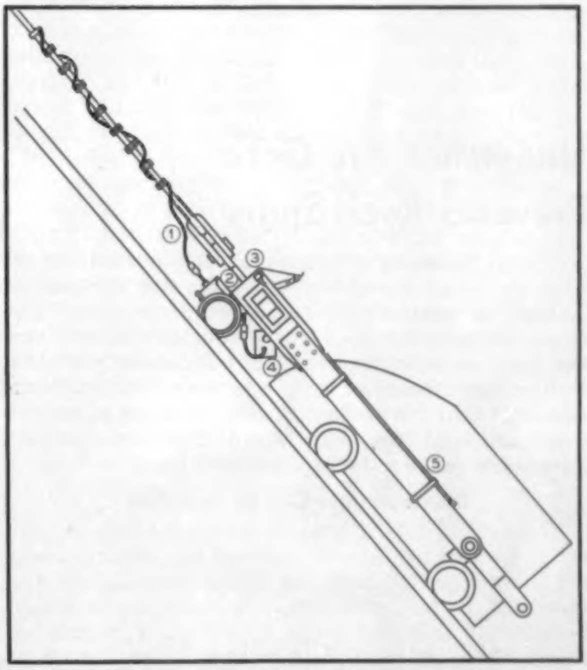
At this time consideration was also given the possibility of stranding insulated copper conductors in the core of the hoisting cable. The flat cable used on the service hoist of the Morning mine was made up of 13 strands of ⅜-in. diam steel cable. The strands, of 4x7 construction, were laid side by side and sewed with soft iron wire, forming a hoisting cable ⅜x4¼ in. During 1940 one hoisting cable was constructed in which two strands were specially made. In each of these two strands, two of the ¼ strands contained an insulated copper wire. This cable was tried, but the copper conductors grounded so quickly that it was never of any service.

After some difficulty with war priorities, the Electronic Signal, developed by R. L. Rutherford of Superior, Ariz., was placed in operation at the Morning mine in 1945. Functioning on a radio frequency near 450 kc, the unit operated on a carrier-current principle, using the hoisting cable as the conductor between cage and hoist. This unit operated more or less continuously until the deep section of the mine was shut down in October 1953.

At times there was great difficulty due to moisture in the air and rubbing of the hoisting cable against the shaft timbers when the cage was at the lower depths. Dead spots occurring in the shaft were invariably caused by the hoisting cable touching the timber at some point above the cage and shorting out the signal. As an extra precaution, waterproof varnishes were used to seal out the moisture, and rubber-faced rollers placed in the shaft to keep the hoisting cable free of the timber not only cut down wear but also facilitated operation of the radio signal.

An attempt was also made to overcome dead spots by stringing a copper wire, insulated from the timber, above and below where the hoisting cable touched the timber, so that the wire would pick up the signal below when it was shorted and carry it across the interruption. This was not successful. In places where the cable rubbed the shaft timber next to the cage guides, the rollers could not be used. In most of these instances, facing the timber with old rubber conveyor belting solved the problem.

In 1952 the cages of both hoisting compartments at the Galena mine were equipped with electronic



Emergency signal installation on the Page mine skip in the Coeur d'Alene district. The equipment has functioned satisfactorily throughout the period of operation. The numbers in the drawing are: 1) antenna; 2) transmitter; 3) pull bob; 4) battery; and 5) pipe.

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signals to supplement the conventional station signal. Extreme care has to be taken to seal out moisture, since cage compartments are upcast and the moisture content of the air is high. In all the electronic signal installations, an extra feature has been obtained by connecting to the slack rope safety. An electric switch mounted on the cage crosshead is actuated by the safety dog mechanism. Should slack rope occur, the safety mechanism sets the dogs and closes the switch, giving a continuous warning signal to the hoisting engineer.

Signal System in Inclined Shaft

In the Page mine, the last to be equipped with an electronic signal, the application differs from the others, as the shaft slopes 52° from the horizontal. In most instances the application has been in vertical shafts with the skip and cage electrically isolated from ground by floating between wooden guides, leaving only the hoisting rope as a conductor of radio frequency from the skip transmitter to the receiver located at the shaft collar. At the Page mine, however, the skip operates on an inclined track. The rails are bonded and then connected to the mine plant ground system. The output of the transmitter on the skip is connected to the hoisting rope by an insulated wire wound about the rope attachment. No effort has been made to insulate the hoisting rope from the skip. The cable rides on rubber-faced rollers. Even with these conditions the signal received is strong for full length of shaft.

The inclined shaft also introduced the problem of holding upright the battery providing power for the transmitter, since the tilt of the skip changes about 40° when the skip is run out onto a station from its position in the shaft. This was solved by a pivotal battery cabinet that remains upright regardless of cage position. The cabinet is lined with ¼-in. sponge rubber to absorb shocks. The battery is a 150 amp-hr automobile type.

All the units are mounted on the skip pony truck and interconnected with waterproof cable connectors so that any unit can be changed quickly.

The West compartment set operates on a carrier frequency of 450 kc, the East compartment set on 275 kc. This difference in carrier frequency is greater than necessary but lends itself to quicker adjustment and reduces possibility of cross-signaling between compartments.

Receivers are located in a reinforced concrete shelter adjacent to the shaft collar. Sponge rubber mountings on the base of the receivers help arrest microphonic tones set up in the receivers due to vibrations from the headframe during hoisting.

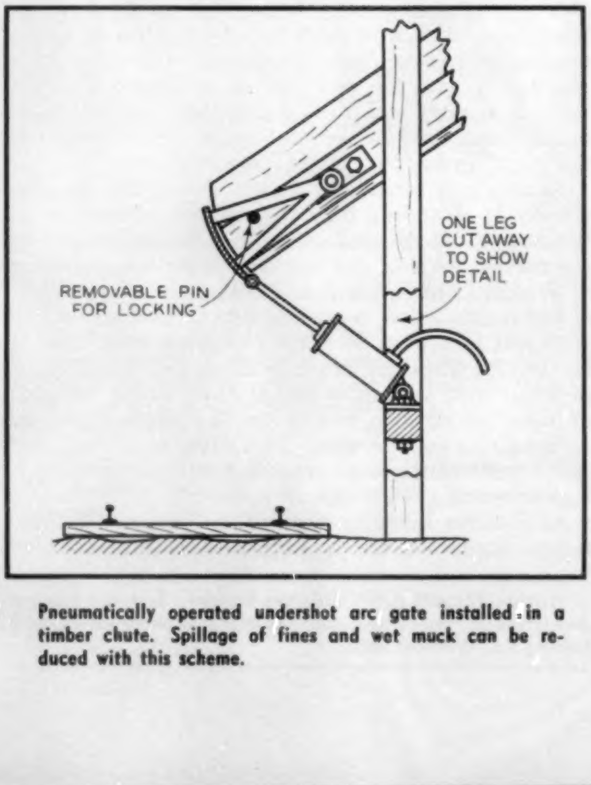
The receiving antennas lie parallel and between the two rails for each compartment. The wires start near the skip dump and extend almost to the shaft collar. At first it was thought that if the antennas were placed in the shaft below the collar it would eliminate radio interference caused by electrical equipment located on surface, but surface location proved best.

Undershot Arc Gate Prevents Rock Spills

Chutes handling ore with a high percentage of fines or large quantities of water are frequently difficult to control with a standard arc gate. The larger rocks in the ore prevent complete closing and the finer material continues to run under the gate. It has been reported from operations in Southern Rhodesia that the undershot gate produces a positive interruption of flow. This type of installation is best adapted to large cylinder-operated gates.

Disadvantages Can Be Remedied

The gate is not without its disadvantages. As the arc is pushed up into the moving ore stream, rocks often are deflected from the upper edge, falling into the drift. In fact, many have abandoned the design because of this difficulty. However, a curtain of heavy chain or steel plate hanging over the lip of the chute will eliminate this problem. The curtain should be suspended as far down on the chute as possible without interfering with the flow. Trolley wires adjacent to the ore chute should be shielded from flying rock.



Pneumatically operated undershot arc gate installed in a timber chute. Spillage of fines and wet muck can be reduced with this scheme.

Blasting Research Leads to New Theories And Reductions in Blasting Costs

by B. J. Kochanowsky

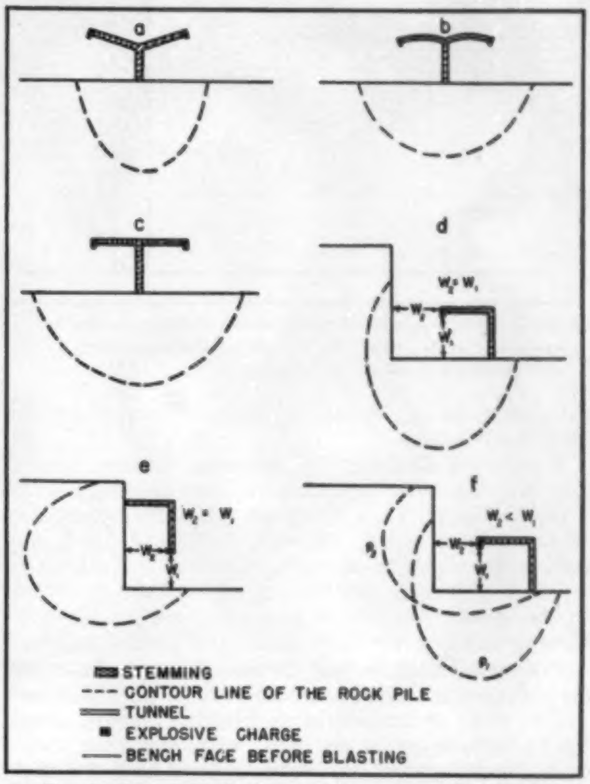
TO improve blasting methods it is necessary to know how the explosive force acts and how rock resists this force. Because of the tremendous power developed within milliseconds and the great number of other factors directly affecting the technical and economic results, an analysis of the fundamentals of blasting theory is difficult. But since the rules used for layout design and for calculations of size of explosive charges are based on theoretical assumptions, complete knowledge of blasting theory has great practical importance in mining.

Analysis of Blasting Theory: It is interesting to note the opinion of blasting experts with respect to contemporary blasting theories. F. Stussi,[1] Professor of the University of Zurich, stated: "We do not have enough experience yet to change our army engineering regulations in blasting and base it on new fundamentals. It is our duty to collect more practical data and to do more research in blasting to close this gap." K. H. Fraenkel,[2] editor of the *Manual on Rock Blasting* published in 1953 in Sweden and written by well-known Swedish, German, Swiss, and French blasting and explosive experts, said: "To the best of our knowledge no suitable formulas for civil blasting work are to be found in the American, French or German literature."

Present blasting theory is based upon two assumptions. 1) The blasting force of explosive acts in concentrical and spherical form. 2) Rock resistance against the explosive force is directly proportional to the strength characteristics of the rock.

The first classical formula based on theoretical fundamental in blasting theory for explosive charge calculation was introduced by Vauban, a military engineer who lived 300 years ago. It was Vauban who proposed the famous formula $L = w^3 q$, where L is the explosive charge, w = line of least resistance, and q = specific explosive consumption proportional to the weight of rock. Later engineers used q as proportional to the strength of the rock. Since Vauban's time different suggestions concerning blasting theory have been proposed. However, the principles stated at that time so affected the thinking of later generations that his formula is still in use and practically unchanged.

The first controversy concerned the form of crater. It was found that geological features of rock affected its form. The factor q was analyzed thoroughly by Lares[3] and later by Ohnesorge,[4] Weichelt,[5] Bendel,[6] and others, but the assumption remained that resistance against explosive force is directly proportional to the strength of the rock blasted. The greatest controversy, which has not yet been settled, concerned w. It was noted that w^2 is more appropriate for long lines of resistance and w^3 for lines of resistance less than 15 ft. Based on the assumption that the explosive force acts concentrically and spherically, spacings between charges were limited to distances not greater than the length of line of least resistance. Sometimes larger spacing is recommended, but this is due to the advantageous geological and physical properties of rock and not to the action of an explosive force as such.



Figs. 1a through 1f—Position and form of rock pile resulting from coyote tunnel blasting.

In addition to the classical formula, empirical formulas are used widely. These state that the explosive charge is directly proportional to the volume of blasted rock in cubic yards, and the amounts of explosive required are usually expressed in pounds of explosive per cubic yard of rock.

Empirical and classical formulas are contradictory. In the empirical formula, but not in the classical formula, explosive charge is taken proportional to all three space axes: line of least resistance, spacing, and bench height. In spite of this contradiction, both formulas give good results. This is possible because as now practiced the explosive charge calculation for heavy burdens need not be highly accurate. Each, open pit or quarry, usually works with a certain relation between bench height and line of least resistance and between charge spacing and line of least resistance. When these relations are changed, however, the specific explosive consumption q changes greatly. This is one of the reasons why the principles on which the formulas are based appear to be incorrect.

In addition to the formulas discussed, others exist and are based more or less on the same theoretical

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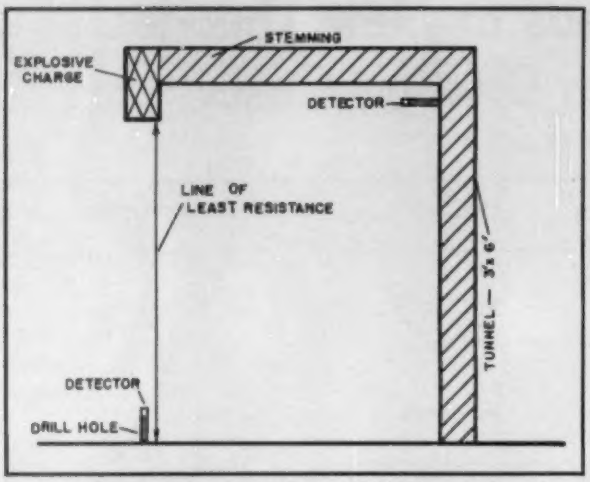


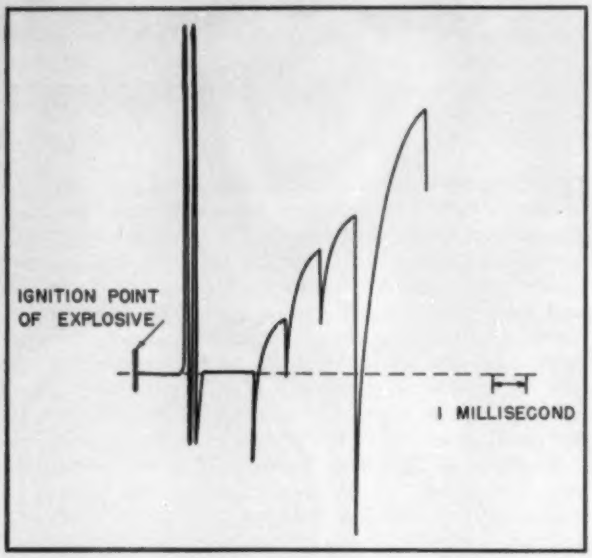


Fig. 2 (above)—Layout of coyote tunnel blasting showing arrangement of detectors. Fig. 3 (right)—Schematic characteristic taken by electronic oscillograph.

principles. K. H. Fraenkel[2] recently introduced an improved version.

Results of Research in Blasting: Coyote tunnel and drillhole blasting methods were investigated at Thyssen-Krupp Co.'s Rheinische Kalksteinwerke at Wulfrath, Germany, between 1933 and 1939 and during the summer of 1954. Rheinische Kalksteinwerke is probably the second largest lime producer in the world and the largest dolomite producer in Europe. In a quarry that is the largest producer in Europe over 2000 coyote tunnels were blasted, about 100 per year, with charges up to 10,000 lb per chamber.

The new principles of a blasting theory were established as early as 1933, with resulting technical improvements and reductions of cost. Further experience and research confirmed the correctness of the assumptions underlying the new theory. These assumptions are:

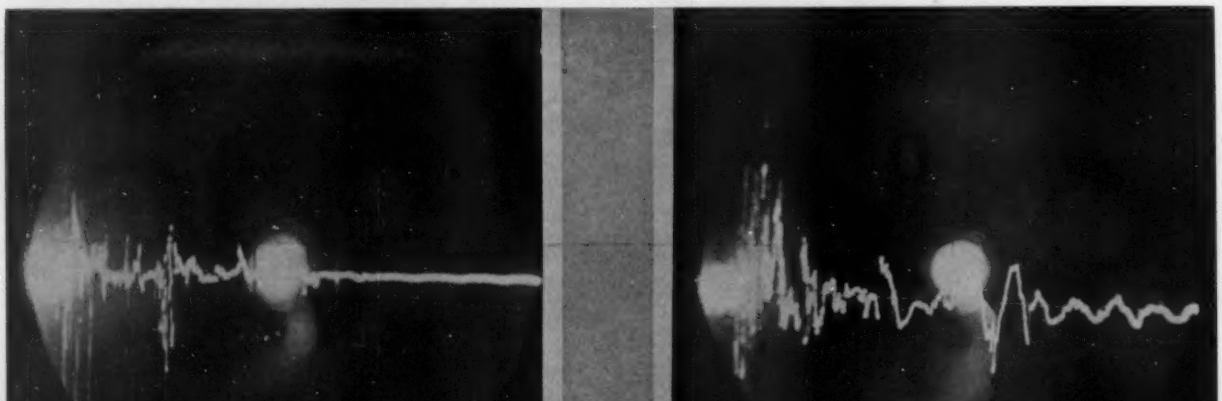
1) The blasting force of the explosive used in hole, chamber, or coyote acts in nonspherical form.

2) The rock resistance against the explosive force is not directly proportional to the strength characteristics of the rock.

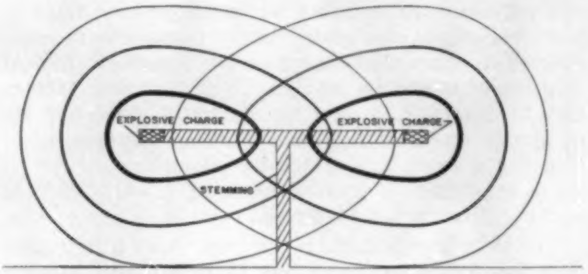
3) The blasting resistance of rock in the direction of the three different axes, such as the line of least resistance, the bench height, and the charge spacing, is not directly proportional to the length of these axes. Certain relations exist between blasting resistance in these three axes.

Theory Concerning Nonspherical Action of Explosive Force: The shape of the explosive charge and the location and direction of the detonator within the explosive charge immediately influence the form, direction, concentration, and violence of the blast force propagation. Propagation of the explosive force then is affected by the opposing resistance of the stemming and the rock face within the explosive chamber. Finally the propagation of the explosive force is influenced by the form, direction, and cross-section of the coyote or drillhole. In addition to these factors, the total blast effect depends on the tectonic and physical rock properties. How far each of these many factors separately affects the explosive force in producing a nonspherical propagation still is difficult to determine.

In 1888 Munroe found that the explosive force and its direction depends on the charge shape, which is important in military work. In mining, the shaped charge also is used to blast large rock pieces. It is suspected that the shape of the explosive charge can control the form of propagation of the explosive force, especially in coyote tunnel blasting.



Figs. 4a and 4b—Characteristics of wave concentration taken by electronic oscilloscope. Wave concentration due to expansion gas action is more violent (left) in the direction of the side arm of the coyote tunnel and less violent (right) in the direction of the line of least resistance.



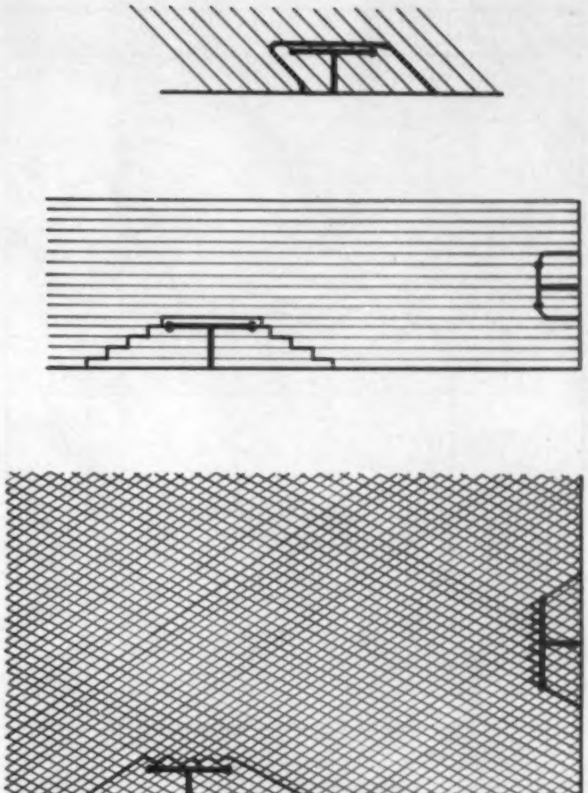


Fig. 5 (above)—Approximate form of a pressure front due to expansion of explosive gases. Fig. 6 (right)—Effects of tectonics on blasting.

The detonator produces the shock in one direction only, and this affects direction of the explosive force propagation. It is known also that the damage to a steel pipe loaded with explosive and detonated at both ends will be greatest at the center of the pipe. This is not the result of greater energy production but rather of accumulating force at a given point. As only a small part of the explosive force is utilized for rock breakage, it is of practical interest to know how to concentrate the blast force and how to guide it in a desired direction.

In coyote tunnel blasting especially, it is difficult to avoid empty spaces between the explosive charges and stemming. Stemming itself, if not of concrete, is never absolutely compact and does not have the same resistance as the rock face of the explosive chamber. Before the blast force breaks the rock, the explosive force will seek an escape in the direction of least resistance, that is, in the direction of empty spaces and stemming. Therefore the care with which a coyote is stemmed, the type of stemming material, and the direction of the side arm of the coyote where the explosive charge is placed will affect the direction and concentration of the explosive forces before the rock is definitely fractured and moved. In coyote tunnel blasting the rock starts to move between 30 and approximately 100 milliseconds after initiation, while the detonation wave and following pressure of the explosive gases starts to act within a time much shorter than 10 milliseconds. The same sequence was observed in short holes drilled into rock or coal by means of a movie camera capable of taking 1200 to 2000 pictures per sec. These experiments made in Germany and in Japan showed that the stemming began to move after 2 milliseconds, but the rock did not move until after 7 milliseconds.

The nonspherical action of the blasting force can be evaluated by comparison of the amount, form, and location of the blasted rock pile. It is evident that in a coyote loaded with an explosive but not stemmed, the whole blast force would escape as in a cannon through the side arm and entry. Experimental blasting of a stemmed entry and a partly stemmed coyote tunnel resulted in the stemming being blown out. The width and depth action of the blast was small, the rock pile was narrow, and the cost was high. The longer the entry of the coyote tunnel, of course, the less the effect of this kind will be. All subsequent experiments discussed are with completely stemmed coyote tunnels. Figs. 1a-1c prove that the explosive force is deviated in the direction of a side arm of the coyote. This is the reason, in Fig. 1a, that the width and depth blast action is small, the rock pile stretched, and the blast cost high. For the same reason, in the coyote shown in Fig. 1b, more explosive must be used to obtain the same blasting effect. The economic result is shown in Fig. 1c. All three had the same explosive charge, burden, and spacing.

In Figs. 1d and 1e, a certain explosive charge is placed at the same point, but the location and direction of the coyote tunnel with respect to this point and to the bench face are different. As both figures show, the location of the rock pile also is different, because the nonspherical action of explosive force has a tendency to escape through the side arm and entry of the coyote. In spite of the fact that in Fig. 1f w_2 is shorter than w_1, the rock pile is located as shown by the contour line p_1 and not by the line p_2.

Through experiments it was found that an explosive charge, calculated for a certain length of line of least resistance but in different charge spacing and bench height, can vary three times or more and still produce a normal effect in coyote tunnel blasting. This is possible because of nonspherical propagation of explosive force.

Another proof of nonspherical explosive force propagation was made using an electronic oscilloscope furnished by Philips of Hamburg, Germany. Several detectors were placed along the line of least resistance and others in the side arm of the coyote tunnel, which usually is at right angles to the line of least resistance. The detectors were placed and stemmed in the short holes. The distance between detectors and explosive charge in each direction was the same. Fig. 2 shows the general arrangement. Fig. 3 shows the typical wave characteristic obtained from these experiments. It is assumed that the first wave concentration is due to the detonation wave action and the second due to the expansion pressure of explosive gases. The detonation shock affects the amount of fragmentation, but it is the expansion force of explosive gases that breaks and displaces the rock. In both locations the wave con-

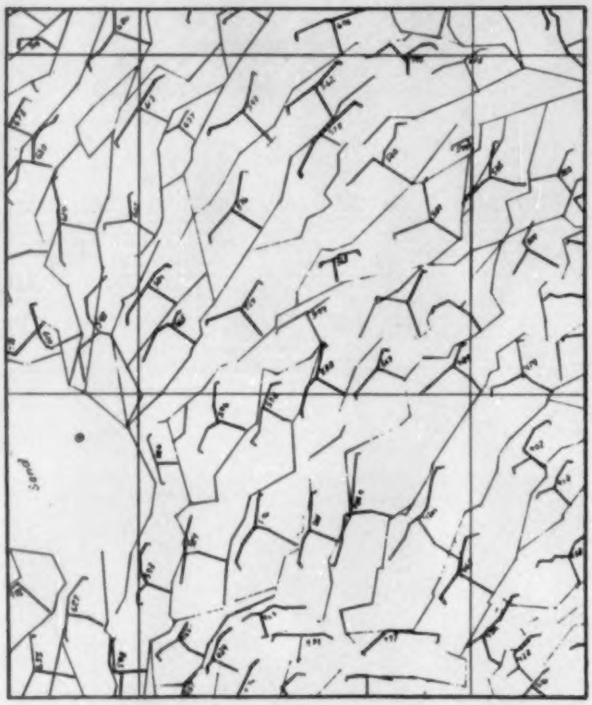


Fig. 7—Partial view of the plan showing about 70 coyote tunnel blastings.

centrations due to detonation shock were found to be similar, but the wave concentrations due to the expansion gases were different. It can be seen that wave concentration due to expansion gas action is more violent in the direction of the side arm of the coyote, Fig. 4a, and less violent in the direction of line of least resistance, Fig. 4b. Repetition of experiments gave the same results.

Fig. 5 represents the approximate form of a pressure front developed by the expansion of explosive gases. The total blast effect is the result of blast force action and resistance of the rock. More investigation is necessary to find the exact form of these curves and rock stress curves.

Ignorance of the nonspherical action of blasting forces is the reason for many failures in civil and military blasting.

Theory Concerning Rock Resistance: Of the many factors that may affect rock resistance, tectonic conditions are especially important. Fig. 6 shows how enormously tectonic conditions control the amount of rock blasted.

Because of the nonspherical action of explosive force and influence of rock tectonics, the blasted rock generally does not have a funnel-shaped crater. This is confirmed by studying plans of 2000 coyote tunnels, where the bench face before and after blasting can be seen, Fig. 7. For the same reason the blast effect cannot be measured by comparison of the angle formed by the sides of the crater with an angle of 90° at the point where the explosive is placed, because the rock tectonics affect the angle. Larger charges will produce stronger blowout effect of the rock, but not necessarily a change of angle.

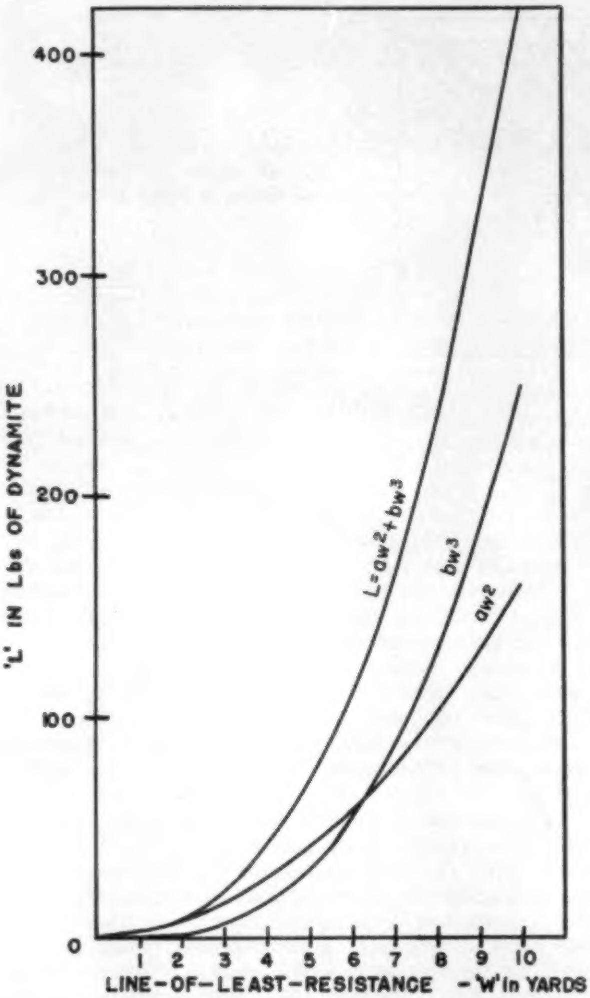
Vauban thought the main purpose of the explosive force was to lift the rock. About 230 years ago B. F. de Belidor[7] postulated that a part of the explosive force breaks the rock and another part lifts the rock. Neither opinion found recognition. Explosive engineers realized and have accepted until now that the explosive force must be taken proportional to the strength of the rock. Many factors were considered in order that rock resistance under different conditions might be analyzed. Since these factors can be determined only by estimate, more sources of errors were introduced. Blasting experts agree that for a short line of least resistance, $L = w^2 q$; for a long line of least resistance, $L = w^3 n q$ is better, where n is a coefficient related to w.

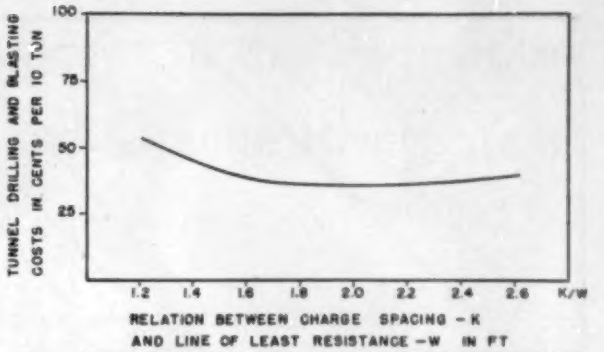
The theory of Belidor is the best, since it is logical that the explosive force has to break and lift the rock. It is necessary to know how much of this force is needed for each mentioned purpose, or one may be so small compared with another that it can be omitted without affecting the result. The rock breaking force will be proportional to the square of the line of least resistance, and lifting force will be proportional to the cube of line of least resistance. Thus the explosive charge $L = aw^2 + bw^3$, where a is the coefficient in pounds of explosive per square yard of rock which characterizes the strength of rock, and b is the coefficient in pounds of explosive per cubic yard which expresses the force necessary to lift a cubic yard of rock a certain height. This formula is useful only for an explosive charge located under a horizontal surface, so that height and length of line of least resistance are the same. For bench blasting, the bench height must be taken into consideration. Fig. 8 gives the relation between explosive charge L and line of least resistance w, where a is 1.6 lb of dynamite per sq yd and b equal to 0.25 lb per cu yd. More exact figures may be obtained in the future through more research.

This interpretation makes it possible to explain different phenomena. Considering the curves in Fig. 8, for a short line of least resistance the explosive charge is almost entirely proportional to w^2 and for a long line of least resistance it is almost entirely proportional to w^3. For a short line of least resistance, where the value of aw^2 is much larger than bw^3, the explosive force is proportional to the strength of the rock, but the longer the line of least resistance the less significant this relationship becomes. The same formula and diagram explain why the overloading of an explosive charge is more dangerous for blasting with a short line of least resistance, but not so dangerous with a long line of least resistance. As the force necessary to break the rock is greater than that necessary to cleave it, the tectonic conditions of the rock must be considered in explosive charge calculations. These theories and the formula explain why certain rocks with higher strength require the same or less explosive charge than rocks of lower strength.

Owing to the nonspherical action of explosive force and the interpretation of the classical formula $L = aw^2 + bw^3$, a certain relation must exist between the explosive charge and the three axes: line of least resistance w, bench height H, and charge spacing. Therefore the explosive charge cannot be taken directly proportional to these three axes. This relation was found empirically to be $L = w\ (\frac{1}{4} w + t)\ (w + H)\ c$ for T-shaped coyote tunnel blasting with two explosive charges, where t is the length of side arm of the coyote between the charge and the junction of side arm and coyote tunnel entry and c specific explosive consumption.

Technical Improvements of Blasting Methods: The German Safety Authority permits only two explosive charges for each coyote tunnel blast. This restriction, and the need for lower costs, resulted





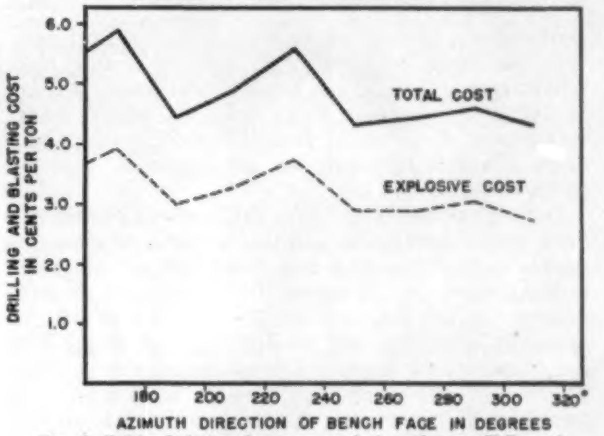


Fig. 8 (left)—Relation between explosive charge, "L", and line of least resistance, "w." Fig. 9 (top)—Coyote tunnel drilling and blasting costs vs relation between charge spacing, "k", and line of least resistance, "w", expressed in feet. Fig. 10 (above)—Drilling and blasting cost affected by tectonics and direction of bench face with respect to predominant trends of the rock, viz., strike and joints.

in the development of the nonspherical explosion force theory for coyote tunnel blasting. The usual method of placing the explosive chamber not farther than the length of line of least resistance was changed in 1933 to methods based on this new theory. Experiments demonstrated that in favorable conditions the charge spacing can be taken up to 2.7 times and more of the length of the line of least resistance. For limestone at Wulfrath the best economic value is between 1.8 and 2.2 times the length of line of least resistance. As Fig. 9 shows, the principle of nonspherical action explosive force can be extremely useful for locating and calculating explosive charges.

Owing to tectonic rock conditions the change in direction of the bench face greatly affects the amount of blasted rock, see Fig. 6; about 20 pct of the cost of explosives at Wulfrath, Fig. 10, was saved by changing the direction of the bench face only, with respect to the predominant structural trends of the formation, i.e., strike and joints.

Coyote tunnel blasting can compete with the drillhole method where crushing is not required, as in stripping, or where the rock is very hard to

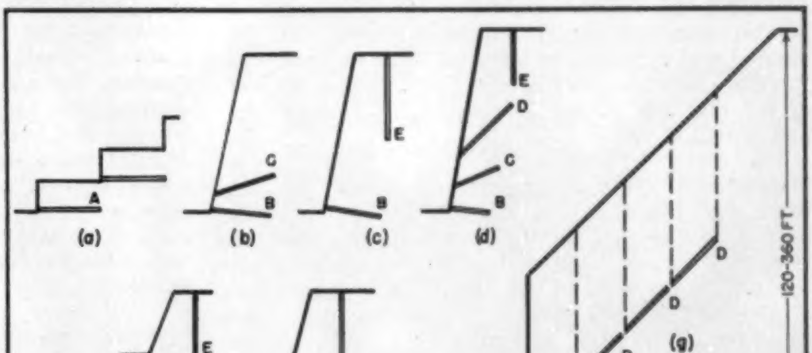


Fig. 11—Various patterns of drillholes on a bench. The first hole is drilled and blasted before the second one, etc. Approximate height of the inclined bench face of sketch G is 120 to 360 ft.

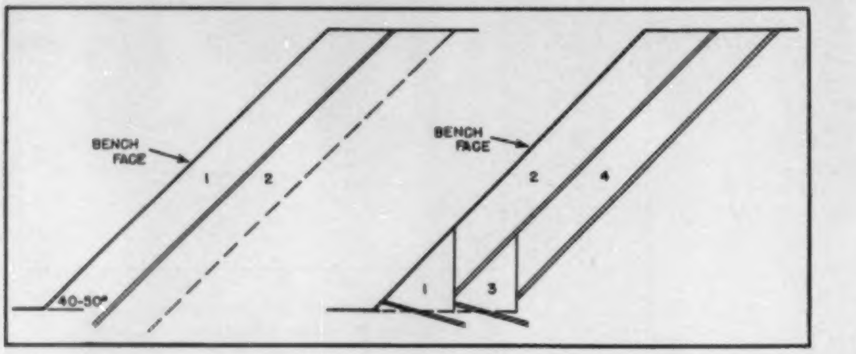


Fig. 12—Layout of inclined-hole drilling in high benches.

drill and the geology of the rock is such that it need only be lifted to be broken into crushable size. Where rock extraction in one location must be completed in a relatively short time, or where initial investment or operating capital is insufficient to buy expensive drilling machines, coyote tunnel blasting can be used.

During the last few years drilling equipment has been highly developed, and this is one of the reasons coyote tunnel blasting was displaced by blasthole drilling methods. However, little has been done to improve coyote blasting. At Wulfrath 4.5 to 6 ft per manshift was obtained in drifting and about 9 ft per manshift for loading and stemming the coyotes. There are still many questions to be solved, and technical improvements through mechanization and cost reduction can be expected.

Indications are that these same principles can be applied to drillhole blasting. Six different types of drillholes, A-F, are sketched in Fig. 11. Many combinations are possible, and hole *F* is typical for holes of large diameter. After each kind of hole and hole combination shown was examined, it was found that the hole given in Fig. 11g was the most economical. In a limestone quarry with a bench of 360 ft, 20 holes of 2-in. diam were drilled 24 to 30 ft long and 18 ft apart. The holes were loaded with 2750 lb explosive (half ammonia and half gelatin) with which 50,000 tons of rock were blasted, or 17.5 tons per lb of explosive and about 90 tons per ft of hole. Part of the explosive was used for chambering the holes. But when larger diameters or shorter holes are used chambering is not necessary. Because of the bench face inclination, the face can be very high without danger and without disturbing the loading operation. Production can be concentrated on fewer levels and fewer operating points; therefore larger equipment units can be applied and costs can be lowered. This method was successfully introduced before World War II in one of the quarries at the Rheinische Kalksteinwerke and is still in use.

The method presented in Fig. 12 could allow utilization of the above-mentioned advantages and work with less explosive and less footage per rock unit. In the vertical blasthole method, the explosive is mostly concentrated at the bottom, partly even beyond the toe level of the bench, where resistance of the rock is very great. This causes high consumption of explosive and requires a large footage of hole per ton of rock. The suggested method with inclined holes needs less explosive and therefore the diameter of the hole or the hole footage is smaller.

Because time was short only a few experiments were made with this method last summer, but good results were obtained. Many combinations of loading and firing are possible and further research along this line is warranted. In hard rock and coal stripping this method could be of interest. In taconite, where drilling and blasting is a problem and where jet piercing is in use, this method may prove successful.

With normal drilling equipment many difficulties arise because it is necessary to drill at an angle. High-speed rotation machines could be useful, because the diameter of the hole can be reduced and deviations of the hole are less likely. If this method should prove successful, equipment for drilling inclined holes more efficiently could be developed.

Research in the field of blasting along the lines of drilling methods and loading and stemming of explosives undoubtedly will lead to further improvements. Investigation of the effect of a shaped charge or cartridge in large holes may be worthwhile.

The possible improvement of hole loading by the use of compressed air appeared at first to be too dangerous. In 1953 in Germany a safer application of this method was developed and today different companies are loading explosives by the use of compressed air with good success. Obviously the time of loading is greatly reduced by this method. A 15-ft hole of 1.5 in. diam can, for example, be loaded with 25 cartridges in 30 sec and the charge is more compact. This again means better utilization of the explosive force or less footage of hole.

While blasting techniques appear to be satisfactory at the present time, only a small portion of the explosive force is utilized. On this basis any research that would lead to an increase in useful work done by explosives would be beneficial.

Acknowledgments

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Occurrence of Mineral Deposits in the Pegmatites Of the Karibib-Omaruru and Orange River Areas Of South West Africa

Pegmatites of these areas have become important sources of beryl and lepidolite and have yielded cassiterite, columbite-tantalite, and other minerals. Examination of about 60 of these pegmatites leads the author to question the opinion of earlier investigators that the concentrations of beryl, lepidolite, and columbite-tantalite found have mostly formed by hydrothermal or pneumatolytic replacement of previously formed quartz-feldspar pegmatites. The author concludes, on the contrary, that present knowledge of the occurrence of minerals in zoned pegmatites can be applied to prospecting and mining of pegmatite deposits in these two areas of South West Africa.

by Eugene N. Cameron

PEGMATITES occur in abundance in certain areas of South West Africa and in adjacent parts of northern Cape Province in the Union of South Africa. Some of the pegmatite deposits were prospected before World War I, and intermittent mining was done during the period between the two World Wars. The deposits of the Jooste lithium mines became an important source of lepidolite, and beryl, columbite-tantalite, wolframite, and other minerals were produced. Since World War II prospecting and mining have been carried on vigorously, with the result that South West Africa produced nearly 3000 tons of beryl during 1949 through 1953, together with more than 40,000 tons of lithium minerals, chiefly lepidolite and petalite. Small amounts of tantalite, columbite, and other minerals have also been produced during the postwar period.

Most of this mineral production has come from two pegmatite areas roughly outlined in Fig. 1. One is the Karibib-Omaruru area of north central South West Africa. The second is the northeastern part of the Orange River pegmatite area, which extends into adjacent parts of Namaqualand, in northern Cape Province of the Union of South Africa.

The writer visited the two pegmatite areas in July 1951. The visit was brief, but it gave an opportunity to compare some of the pegmatites of these areas with those studied and described in detail by many investigators in the U. S., Brazil, and Canada during and since World War II.[1-11] The writer has attempted to determine, in a preliminary way, whether the concepts of internal structure and distribution of minerals in pegmatite bodies developed out of these studies are applicable to prospecting and exploration of pegmatites in South West Africa.

Previous Work

In an important series of papers (1929 to 1942) T. W. Gevers, H. F. Frommurze, S. H. Haughton, G. K. Joubert, and other geologists of the Geological Survey of South Africa described and discussed the pegmatites of the two areas.[12-17] These works are the principal sources of information on the pegmatite mineral deposits of South West Africa. The investigations showed that in the two areas pegmatites are profusely distributed in pre-Cambrian rocks. These rocks are meta-igneous and metasedimentary units that have been folded and subsequently invaded by younger pre-Cambrian granites and by other igneous rocks. The pegmatites are considered to be genetically related to the pre-Cambrian granites. Pegmatites occur in the granite bodies themselves but are most abundant in the surrounding metamorphic rocks, a pattern repeated in many pegmatite districts of the world.

Fig. 1—Index map of South West Africa showing pegmatite areas visited.

The origin of the pegmatites and the factors controlling the occurrence of mineral deposits in them were discussed at length by Gevers and Frommurze (1929)[12] and later by Gevers [14, 15] (pp. 41-51, Ref.

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Discussion of this paper, TP 4075I, may be sent (2 copies) to AIME before Nov. 30, 1955. Manuscript, Dec. 10, 1955. New York Meeting, February 1954.

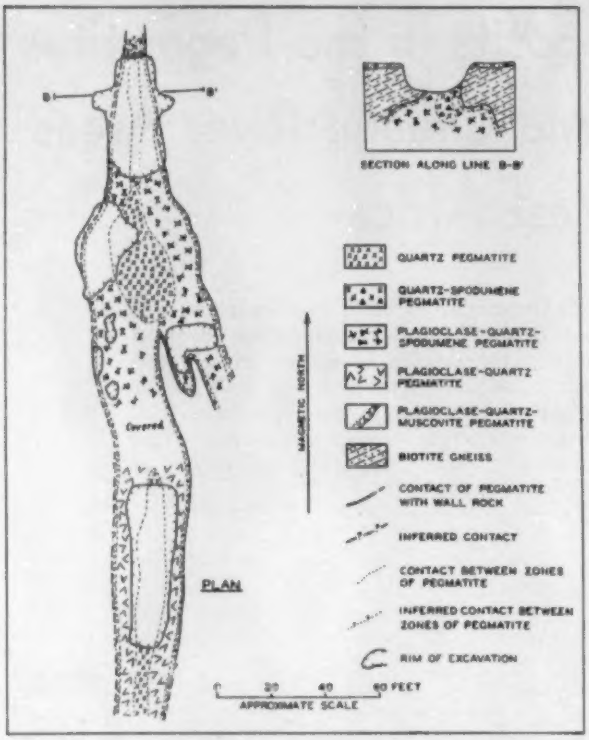


Fig. 2—A pace-compass map of pegmatite on Farm Donkerhoek.

15). Gevers' discussion of the pegmatites south of the Orange River[14] may be cited to illustrate the views presented. He concluded that the pegmatites were developed during successive stages. The first was an epimagmatic stage during which pegmatite magma was intruded and crystallized to form simple pegmatites. These consist essentially of quartz and microcline, with or without minor albite, and with accessory zircon, spessartite, apatite, biotite, magnetite, ilmenite, and titanite in various combinations. The epimagmatic stage was followed by a series of pneumatolytic or hydrothermal stages during which albite, muscovite, tourmaline, cassiterite, columbite-tantalite, lepidolite, spodumene, lithiophyllite, and a variety of other minerals were developed in various amounts and proportions in some of the pegmatites. These minerals formed by replacement of parts of the previously formed simple pegmatites. The development of concentrations of beryl, lithium minerals, cassiterite, and tantalite was referred to the later stages. Gevers' concept of the origin of pegmatite minerals was thus in accord with the views expressed prior to World War II by Schaller (1933),[18] Landes (1933),[19] and others.

In accordance with this concept conclusions were drawn that had considerable economic significance. Gevers stated the most important conclusions in the words (Ref. 14, p. 342):

"Since most mineral occurrences in pegmatites are the result of more or less intense pneumatolytic and hydrothermal alteration of the pegmatitic quartz-feldspar base at fairly high temperatures, the metallic and other elements being introduced initially by fluids of high vapour tension and hence great irruptibility, all pegmatite mineral occurrences are characterized by great irregularity and patchiness."

This conclusion was discouraging to the prospector, for if correct, it meant that there was scant basis for systematic exploration and development of the pegmatite mineral deposits of the region.

General Description of the Pegmatites Examined

The writer examined some 60 pegmatites during the course of his visit, 46 in the Karibib-Omaruru area and the remainder in the Warmbad district. The pegmatites examined cannot be fully representative of the pegmatites of the two areas, but they constitute a random sample of the pegmatites that were then productive or had been prospected. They show a wide range of mineral compositions. At one extreme are those consisting essentially of quartz, plagioclase, and perthite, with accessory muscovite, or biotite, or both, and traces of garnet or tourmaline. At the other extreme are those that also contain beryl, lepidolite, amblygonite, columbite-tantalite, spodumene, cassiterite, topaz, microlite, triphylite,

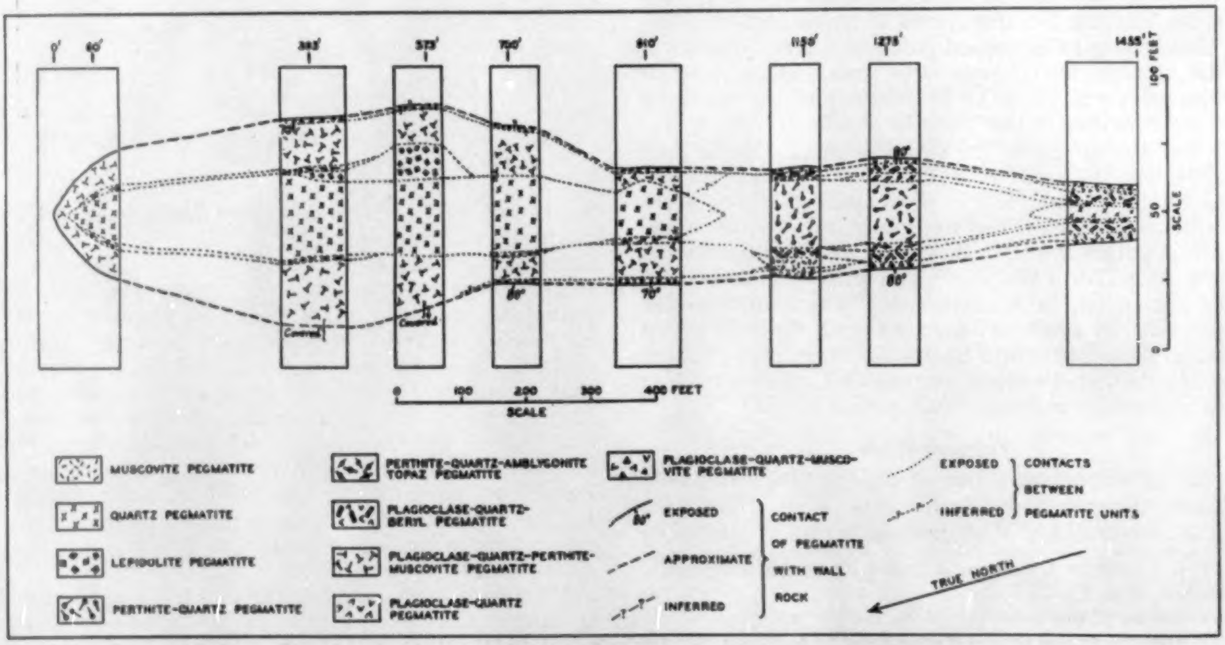


Fig. 3—Sectional plan of Van der Made pegmatite, Erongo Schlucht.

Fig. 4—Outcrops (center and lower right) of northern segment of quartz core of Van der Made pegmatite, Erongo Schlucht. Outer zones of the pegmatite are largely masked by talus at this point. The pegmatite is complexly zoned, but consists essentially of feldspathic wall and outer intermediate zones flanking a core composed of two lenses of quartz.

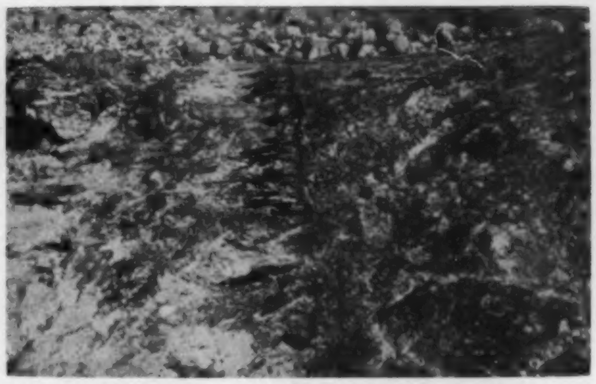


Fig. 5—Hanging wall part of the Van der Made pegmatite, Erongo Schlucht. The contact of pegmatite (left) with granite (right) runs from top to bottom through the center of the photograph. The wall zone is marked by black crystals of tourmaline, the largest nearly 2 ft long, subperpendicular to the contact.

bismuth, and other minerals in various combinations and proportions. Some of the pegmatites examined are of the homogenous type, that is, they show no systematic arrangement of the mineral components. None of these homogenous pegmatites appears to have been productive. Most of the pegmatites examined are inhomogenous, consisting of two or more contrasting lithologic units, and the large majority of these show zonal structures. In some pegmatite bodies zonal structures are poorly developed, but in others they are as strikingly developed as in any pegmatites thus far described from any district. The examples given below illustrate some of the zonal structures observed.

Descriptions of Individual Pegmatites

Pegmatite on Farm Donkerhoek: A pace-compass plan of a tantalite-bearing pegmatite on Farm Donkerhoek is given in Fig. 2. The pegmatite has a distinct zonal structure. The core consists of two lenses of quartz centrally disposed in the pegmatite body. The keel of the northern lens is exposed in a small open cut, and along the under side of the keel an inner intermediate zone of quartz with scattered spodumene crystals is developed. Outside this is a plagioclase-quartz outer intermediate zone that contains scattered spodumene crystals. The counterpart of this zone in the southern part of the pegmatite appears to contain no spodumene and is therefore shown by a separate symbol on the map. The wall zone is 1 to 2 ft thick and is composed of plagioclase and quartz with large books of muscovite. Tantalite in this pegamtite is apparently concentrated in the inner part of the outer intermediate zone. The writer could find nothing to indicate that either tantalite or spodumene developed by replacement of pre-existing pegmatite. The two minerals appear to have formed contemporaneously with other constituents of the zones.

Pegmatites on the Van der Made Claims: A series of pegmatites mined by G. H. Van der Made is exposed on the ridge on the west side of the Erongo Schlucht. Brief descriptions of several of these pegmatites are given by P. J. Rossouw (Ref. 17, pp. 89-90, 107-11, 113-114). The most interesting pegmatite is one that outcrops about halfway up the slope of the ridge. It strikes N 15° E to N 20° E, dips 70° to 80°W, and crops out almost continuously for about 1450 ft. The south end of the body is concealed by overburden. The arrangement of the major lithologic units of this pegmatite is indicated by the sectional plan of Fig. 3, which is based on a pace-compass traverse along the length of the pegmatite together with cross-traverses at intervals dictated largely by the character of the exposures. The transverse scale is exaggerated to make it possible to show some of the narrower units. The complete structure of this complexly zoned pegmatite could be revealed only by detailed mapping, but the major features are believed to be correctly indicated in the diagram. The pegmatite consists essentially of feldspathic wall and outer intermediate zones flanking a core composed of two lenses of quartz, the northern one by far the larger, see Fig. 4. The wall zone (plagioclase-quartz-muscovite pegmatite) along both foot and hanging walls is characterized by numerous black tourmaline crystals up to 2 ft long, Fig. 5, arranged perpendicular or subperpendicular to the contact with the enclosing granite. In the northern part of the pegmatite, a discontinuous inner intermediate zone of lithia mica is developed at intervals. The southern part of the pegmatite contains two particularly striking zones. One is a plagioclase-quartz-amblygonite-topaz zone, the other a plagioclase-quartz-beryl zone containing partly exposed crystals of white beryl up to 20 in. diam and 38 in. long. The beryl-bearing zone is exposed for 300 ft along the hanging wall side of the pegmatite and for a similar distance along the footwall. Owing to its white color, the beryl had been overlooked prior to the writer's visit, but beryl has since been produced from pegmatite.

The plagioclase-quartz-amblygonite-topaz unit is of special interest for two reasons. One is that topaz-bearing units are uncommon in pegmatites (but see, for example, Ref. 5, pp. 63-76). The second is that amblygonite is present in a zone between the wall of the pegmatite and the perthite-quartz zone.

Fig. 6—Gossow pegmatite, Karibib-Omaruru area. The white knob is the quartz core of the pegmatite.

This position is at variance with the sequence of mineral assemblages based on pegmatites of the U. S. studied during the war (Ref. 3, p. 61).

The pegmatite shown in Fig. 3 appears to be the same as one described by P. J. Rossouw (Ref. 17, pp. 107-109, 113,114). Zonal units in the pegmatite are discussed and illustrated in this report, although the overall relationships of the zones are not given. The lithia mica is reported by F. C. Partridge (Ref. 17, p. 113) to be zinnwaldite.

Tantalite was not seen in place by the writer, but according to Rossouw it occurred along the contact between two thin zones included in Fig. 3 in the outer intermediate zone (plagioclase-quartz pegmatite).

Six other pegmatites on this property were examined briefly by the author. They range from bodies composed largely of quartz, feldspar, and muscovite to bodies containing lithia minerals as well. Zonal structures are developed in varying degrees in all six bodies. The commonest arrangement is a thin border zone of quartz and feldspar, a wall zone composed of quartz and feldspar with accessory mica, an intermediate zone composed of coarse, blocky perthite with interstitial quartz, and a core of quartz, in some cases consisting of several segments medially disposed with respect to the walls.

Pegmatite on the Gossow Claim: The pegmatite on the Gossow claim is poorly exposed but is at least 1000 ft long and several hundred feet wide. The outer part of the pegmatite consists largely of perthite, plagioclase, and quartz, but the core, Fig 6, is a mass of quartz about 125 ft long and 50 ft wide. Along the southeast margin of the core there is a narrow plagioclase-quartz-muscovite zone containing accessory columbite-tantalite. This pegmatite is apparently the same as one described by Frommurze and others (Ref. 17, p. 104).

Cassiterite Pegmatites: Cassiterite pegmatites are reported to be numerous in the Karibib-Omaruru area,[12,16] and published descriptions indicate that they are of diverse types. The only cassiterite deposits examined by the writer are those on Ameib Farm. Here banded, finely granular replacement bodies of cassiterite-bearing plagioclase-quartz-muscovite-tourmaline material cuts across the poorly developed zonal structures of pegmatite bodies composed originally of plagioclase, quartz, and perthite. The pegmatites offer clearcut examples of replacement bodies formed at the expense of pre-existing pegmatite.

Tinschmann Mine, Farm Davib Ost: Beryl has been produced at this mine chiefly from eluvium on the slopes of a low hill. The hill is apparently underlain by pegmatite lenses enclosed in a granite-schist complex. At the crest of the hill, a highly irregular pegmatite body is partly exposed. This appears to consist largely of plagioclase-quartz-perthite pegmatite enclosing scattered quartz lenses rimmed or partly rimmed by giant perthite crystals. Beryl has been found adjacent to these pods. The pegmatite has numerous counterparts in the U. S. They are interpreted as poorly zoned bodies in which isolated lenses of quartz take the place of continuous quartz cores, and perthite zones, likewise discontinuous, form complete or incomplete shells around the quartz lenses. As in many American occurrences, graphic granite is present in the Tinschmann pegmatite immediately surrounding the perthite shells.

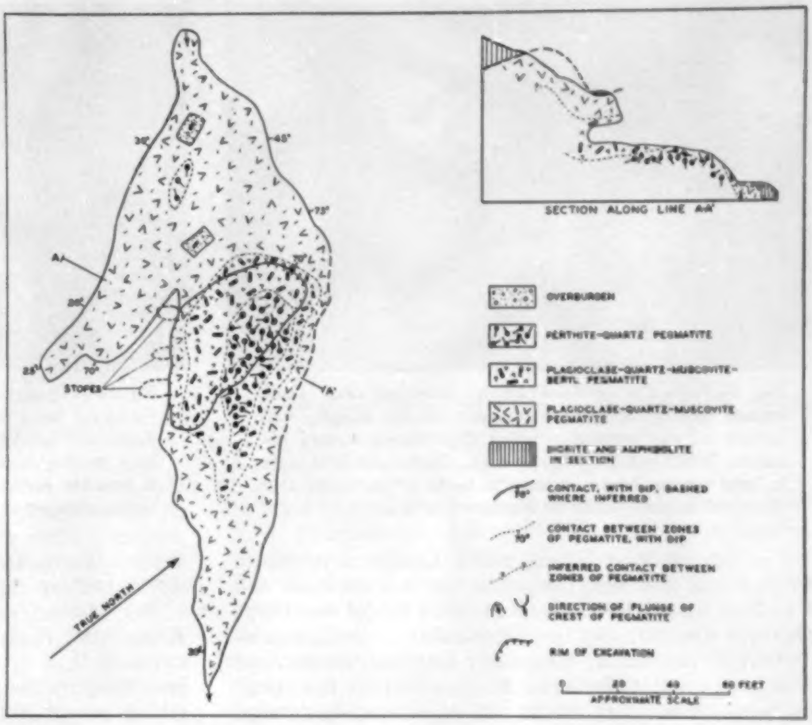
Pegmatites on Farm Okongava: Certain pegmatites on Farm Okongava have cores consisting of giant perthite crystals and interstitial quartz. The cores are separated from the pegmatite walls by plagioclase-quartz-perthite pegmatite. The cores in certain pegmatites are marked by a narrow zone carrying abundant coarse *wedge* muscovite, with or without beryl. Beryl also occurs, however, as crystals scattered through the cores.

One pegmatite examined on Farm Okongava consists of a lepidolite-quartz-plagioclase core enveloped in outer zones consisting of plagioclase, muscovite, and quartz.

Other Beryl, Tantalite, and Lithia Pegmatites of the Karibib-Omaruru Area: Various other pegmatites mined for beryl, tantalite, or lepidolite in the Karibib-Omaruru area were examined. Small replacement bodies of albite or albite and muscovite were seen in some pegmatites, and in the Van der Made and Donkerhoek pegmatites described above, but concentrations of the valuable minerals appear to be unrelated to these bodies. Instead, the distribution of the minerals is governed by zonal structures, and the minable deposits appear to be zones rich in one or more valuable minerals. A possible exception, however, is a tantalite-bearing unit composed of granular muscovite (lithia muscovite?), plagioclase, and quartz seen on the Viljoen claim, Farm Okongava. This may be a replacement body.

Pegmatites on Farm Umeis, Orange River Area: The writer had the pleasure of visiting a series of pegmatite bodies on Farm Umeis, in the Orange River area, in company with Peter Weidner, owner

Fig. 7—Plan of beryl-bearing pegmatite on north branch of Tantalite Valley, Farm Umeis.



and operator. The farm is in the southeastern part of the Umeis sheet.[18] The pegmatites show a considerable range of mineral compositions and internal structures, but a few bodies will serve as examples.

Beryl-Bearing Pegmatite on North Branch of Tantalite Valley: Fig. 7 is a sketch plan of this pegmatite, which is about 200 ft long at surface and about 75 ft wide, striking approximately N 50° W. The country rock consists of amphibolite and diorite. The exposures indicate an undulating lens that plunges gently southeast. At the northwest end its crest passes beneath a steep hillside. To the southeast it appears to plunge beneath wall rock again but must lie at shallow depth.

The pegmatite shows four principal units. Along the contact there is a fine-grained border zone of plagioclase, quartz, and muscovite. Inside this is a wall zone (the outermost zone of Fig. 7) composed essentially of coarse plagioclase, quartz, and large books of muscovite, with accessory garnet, scattered masses of graphic granite, and scattered crystals of beryl. Inside this is an intremediate zone, up to 6 ft in thickness, composed of plagioclase, muscovite, quartz, and beryl, with accessory perthite, and scattered small crystals of columbite-tantalite. A small amount of native bismuth has been reported from this zone. The beryl forms golden to yellow-green crystals 1 in. to nearly 1 ft long and ¼ to 8 in. diam. Muscovite forms large books of the wedge-herringbone type. This zone was being worked chiefly for beryl at the time of visit. The apparent core of the pegmatite consists of giant crystals of perthite embedded in coarse quartz.

The workings are in the part of the intermediate zone overlying the apparent core. Perthite-quartz pegmatite is exposed over a small area to the north and the pits immediately north and south of this area expose the beryl-bearing intermediate zone. The zone may well extend under the hillside to the north.

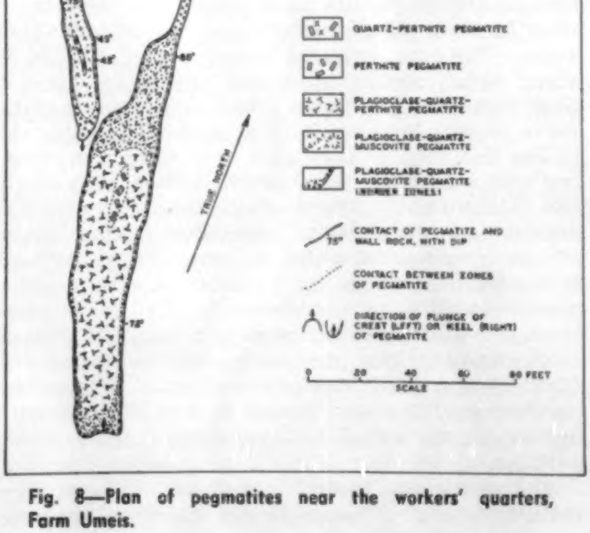


Fig. 8—Plan of pegmatites near the workers' quarters, Farm Umeis.

Pegmatites Near the Workers' Quarters: Two small lenses of pegmatite exposed up valley from the workers' quarters are shown in Fig. 8. The smaller pegmatite strikes N 30° W, and the larger strikes N 10° W on the average. Both lenses dip steeply east: The smaller pegmatite has three zones. The border zone, ½ to 2 in. thick, is fine-grained and consists of quartz with abundant small muscovite books and subordinate plagioclase. Inside this is a wall zone composed essentially of plagioclase, quartz, and muscovite, with accessory perthite. The apparent core of the pegmatite consists of quartz with large, well-formed crystals of perthite. No beryl was observed.

The larger pegmatite, Fig. 9, is 175 ft long and appears to plunge northward. This pegmatite has a border zone 1 to 8 in. thick that is best exposed along the east side. It consists of quartz, muscovite

Fig. 9—Pegmatite on Farm Umeis, Warmbad area. Dark, smooth surfaces opposite man's feet are the hanging wall surface of the pegmatite, which dips steeply toward observer. White patch is in wall zone. Darker patch at right is beryl-bearing border zone, with books of muscovite that stand out as dark knobs on weathered surface.

Fig. 10—Pegmatite at bend of Krom River, Farm Umeis. The prominent ledge running from left to right is the core of the pegmatite, quartz with scattered crystals of perthite. The beryl-bearing zone is in shadows beneath the core. Some 200 ft from the northwest end, the general structure of the pegmatite changes to that shown in Fig. 11.

books up to 8 in. diam, stout blocky crystals of plagioclase, and beryl crystals up to 5 in. long and 1 to 2 in. diam. Both the muscovite books and beryl crystals are oriented perpendicular or subperpendicular to the walls. The outer portion of this zone is fine-grained and richer in quartz than the inner portion. The percentage of beryl is estimated roughly as between 0.5 and 1.0 pct.

The wall zone is developed only at the ends of the pegmatite. It is a coarse-grained mixture of blocky plagioclase, quartz, and muscovite, with a few scattered crystals of beryl. The intermediate zone is similar but also contains perthite. The apparent core is a medial lens composed of large crystals of perthite with massive quartz.

The concentration of beryl in the border zone of this pegmatite is noteworthy. Recovery from interior zones has been negligible. It would appear that either mining must be made to pay on the basis of the beryl content of the border zone or the deposit must be abandoned.

Pegmatite at Bend of Krom River: On the east wall of the Krom River, in the southern part of Farm Umeis, a pegmatite striking N 50° W to N 60° W is exposed over its full length, about 300 ft. It is enclosed in granite gneiss with foliation striking N 70° W to N 75° W and dipping steeply NE. The dip of the pegmatite ranges from vertical to steeply east. At its northwest end the pegmatite splits irregularly into three fingers, and in the northwestern half inclusions of gneiss are present.

The pegmatite is asymmetrically zoned. In general it consists of a perthite-quartz zone enclosing a quartz core with sparsely scattered perthite crystals, Fig. 10. Between 172 and 208 ft from the northwest end, however, the pegmatite has the structure shown in Fig. 11. Along the hanging wall side the perthite-quartz zone is represented only by masses and single large crystals of perthite. Outside this is a zone of blocky plagioclase, wedge muscovite, and quartz 1 to 2 ft thick. This zone is rich in greenish-yellow beryl crystals ⅛ to 4 in. diam and up to 12 in. long. Platy crystals of columbite-tantalite are likewise present. The outermost zone on the hanging wall side consists of plagioclase-quartz-perthite pegmatite. Both the outer zone and the core in places have been sheared roughly parallel to the walls of the pegmatite, and along the shear surfaces small books of muscovite have developed. There is nothing to indicate, however, that the wedge muscovite in the beryl-bearing zone has developed by replacement.

Pegmatite Near Boundary of Farms Umeis and Kinderzitt: A strikingly zoned tabular pegmatite is exposed in a deep ravine on Farm Umeis near the boundary with Farm Kinderzitt. The pegmatite strikes about N 42° W, dips 27° SW, and is enclosed in diorite, biotite schist, and amphibolite. It is more than 1000 ft long and may be divided into two sections with reference to its intersection with the stream. The section northwest of the stream was only partly examined. It shows a fine-grained border zone composed essentially of quartz and feldspar. Inside this is a zone consisting of quartz, plagioclase, and minor amounts of perthite. The middle of the pegmatite is marked by lenses consisting of large perthite crystals and quartz. In one lens these minerals are intermingled, and part of the quartz is interstitial, part graphically intergrown with perthite. Another consists of quartz bordered by large crystals of perthite. One lens is 40 ft long and 6 to 8 ft thick. Total thickness of the pegmatite body where examined north of the river ranges from 12 to 22 ft.

Southeast of the stream the slope is nearly parallel to the pegmatite. The hanging wall country rock has been stripped away, and the pegmatite body is eroded to varying depths, Fig. 12. As a result the outcrop of the pegmatite is as much as 240 ft, although the pegmatite is probably nowhere more than 30 ft thick. The pegmatite here shows other zones. The core, exposed intermittently for 300 ft along strike, consists of quartz. Flanking this is a discontinuous zone of lepidolite, albite, and quartz, parts of which are rich in granular lepidolite. In places this zone is developed only along the hanging wall side of the core, in other places only along the footwall side. The quartz core itself, which is discontinuous, consists of a series of tabular lenses of quartz, a few of which are completely enclosed in lepidolite. Outside the lepidolite zone is another discontinuous zone, not shown in Fig. 12, marked by crystals of perthite up to 6 ft long. This zone corresponds to the perthite bordering one of the quartz lenses northwest of the stream. Outside the perthite zone is a wall zone 3 to 8 ft thick consisting essentially of albite and quartz, with minor perthite.

The above description is believed to cover the main structural elements of this interesting pegma-

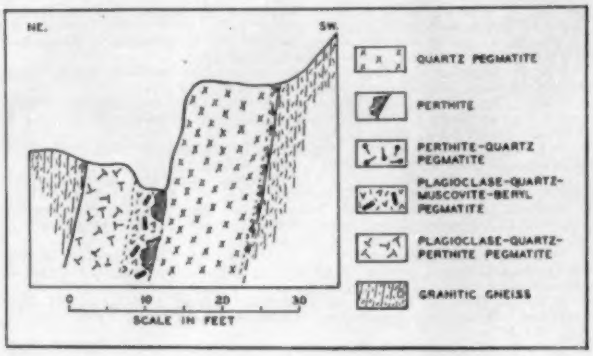
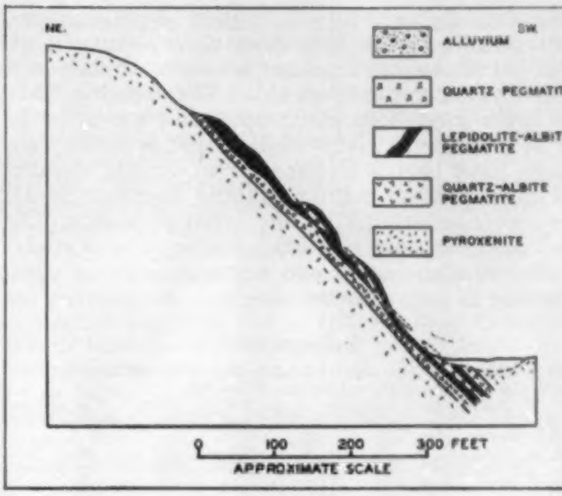


Fig. 11—Structure section of pegmatite at bend of Krom River.

Fig. 12 (right)—Structure section of pegmatite near boundary of Farms Umeis and Kinderzitt.



tite, but only detailed mapping and study could do full justice to it. Since the writer's visit microlite has been found in the outer part of the lepidolite zone, and beryl is also reported to occur in the pegmatite.[30] Hemispheres of cleavelandite may be small replacement bodies developed at the expense of parts of the inner zones.

Pegmatite on the Hill Above Alluvial Block No. 2: Several pegmatites are exposed on the crest of the hill overlooking Alluvial Block No. 2, in the northern part of Farm Umeis. In all, the zonal structures are more or less well developed. Only one could be examined in detail sufficient for description, but others are similar. The pegmatite strikes about N 65° W and is exposed over a distance of 240 ft. It ranges from 5 to 33 ft in outcrop width. The dips of the walls could not be determined, but the trace of the pegmatite across the topography suggests a steep dip. The wall rock is amphibolitized pyroxenite and diorite.

The pegmatite consists of the usual fine-grained border zone, a coarse-grained wall zone, two intermediate zones, and a discontinuous core. The wall zone consists of plagioclase, perthite, and quartz, with minor muscovite. The core is quartz, containing scattered crystals of tantalite and rare beryl. Patches of granular albite, probably replacement bodies, also occur in the core, but neither beryl nor tantalite is associated with them. The largest segment of the core is 20 ft long. It is bordered by giant perthite crystals that form an inner intermediate zone, and outside this is a nearly complete outer intermediate zone composed essentially of graphic granite.

Other Pegmatites on Farm Umeis: Other zoned pegmatites were seen on Farm Umeis, but time available was insufficient for describing them.

Discussion and Conclusions

Even from the brief inspection on which this paper is based, it is evident that zonal structures are present in many of the pegmatites of the two areas visited in South West Africa, that the distribution of the minerals being sought can be analyzed in terms of these and other lithologic and structural units of pegmatites, and that knowledge of these structures can be used to guide prospecting and development. A few of the operators were already using knowledge of zonal structures gained by hard experience, but much of the prospecting and development being done at the time of visit was haphazard and based on the conviction that neither rhyme nor reason governs pegmatite mineral distribution. The experience of investigators during the past 12 years, recorded in a large number of reports, has outmoded this conviction. The writer left South West Africa convinced that few pegmatite districts are of more interest to the student of the internal structures of pegmatite bodies. There is an extraordinary variety of pegmatite mineral deposits in the region. Structural analysis of the pegmatite bodies would greatly assist those prospecting and mining the deposits. The need for such work is the greater because the limits of opencast working have already been reached at some of the mines, and if future development is to be profitable, close attention must be given to possibilities of selective mining. The distinction of barren units from those containing valuable minerals is therefore of increasing importance.

Sequences of mineral assemblages present in the pegmatites examined agree with the general sequence of mineral assemblages recognized in pegmatites of various districts of the U. S. (Ref. 3, p. 61). The topaz and amblygonite-bearing unit seen in the large pegmatite at the Van der Made mine is the only unit occurring in an abnormal position. It seems likely, therefore, that a knowledge of the general sequence can be used in prospecting for pegmatite mineral deposits in the two areas of South West Africa just as it can in the U. S.

Just as time has outmoded the belief that mineral distribution in pegmatites is hopelessly irregular, so also does it necessitate review of any genetic concept upon which the belief was based. In the present case, the genetic question at issue is whether concentrations of beryl, lithia minerals, etc. are ordinarily formed by hydrothermal or pneumatolytic replacement of an original simple quartz-feldspar pegmatite. The writer's observations indicate that they are not. In most of the pegmatites examined, distribution of the minerals in question is governed by zonal patterns, and these minerals appear to be original components of the mineral assemblages that constitute the zones. Cassiterite-bearing replacement bodies were observed in the pegmatites at the Ameib mine, and columbite-tantalite may have formed by later replacement in the main pegmatite on the Van der Made property. Development of deposits of beryl and other minerals in the manner outlined by Gevers, however, appears to have been the exception rather than the rule.

Part of the problem is a confusion over the meaning of evidence that one mineral in a pegmatite has

formed by replacement of another. Such replacements may occur at any stage of development of zonal structure by reaction between crystals already formed and the rest liquid then existing. This has not always been recognized, and too often it has been assumed that if replacement is shown, solutions have been introduced from outside sources and have reacted with pegmatite bodies already completely solidified. For any given pegmatite, this conclusion can only be justified after careful study of mineral distribution and textural relations with reference to internal structure.

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Discussion

Chuquicamata Develops Better Method To Evaluate Core Drill Sludge Samples

by Glenn C. Waterman

Richard Strong (*Oliver Iron Mining Div., U. S. Steel Corp.*)—Mr. Waterman states (p. 59, *Trans.*, January 1954): "Core-sludge combining factors have been calculated for any combination of core-sludge recovery on the basis of several logical assumptions: 1—The sludge sample loses reliability geometrically as sludge recovery drops. 2—The sludge sample should not be used if the percentage of sludge return is less than the percentage of core recovered. 3—A core sample should receive a weighting at least equal to the percentage of core recovery." Assumptions 1 and 2 seem justified at Chuquicamata and most geologists would agree to the validity of assumption 3. However, contrary to the statement quoted above, the core sample does not in general receive a weighting at least equal to the percentage of core recovery when the Chuquicamata method is used. Furthermore, the basic Chuquicamata method is identical to the Longyear or relative volume core-sludge assay combining method. Finally, the Chuquicamata method does not, in its present form, reflect true geometric loss in sludge sample reliability according to the relationship $L = AR^{(n-1)}$.

The basic equations representing the two steps of the Chuquicamata method can be combined algebraically as follows (using the symbology of the original article except as noted):

$$\text{Assay 2} = ASA = \frac{\text{Vol } A + B}{\text{Vol } A} \cdot \text{Assay 1} - \frac{\text{Vol } B}{\text{Vol } A} \cdot \text{Core Assay} \quad [1]$$

$$\text{Combined grade} = \frac{CA \cdot F + ASA\ (100 - F)}{100 \text{ Pct}} \quad [2]$$

where F and $(100 - F)$ are the core and adjusted sludge assay factors from Fig. 3.

Substituting Eqs. 1 and 2 and collecting terms

Combined grade =

$$\frac{CA\,F - \dfrac{\text{Vol B}}{\text{Vol } A}(100\text{—F}) + \text{Assay 1}\,\dfrac{\text{Vol } A + B}{\text{Vol } A}(100\text{—}F)}{100 \text{ Pct}} \quad [3]$$

Eq. 3 is a unified and general statement of the Chuquicamata method. The true core factor includes not only the factor F from Fig. 3 but also the quantity $\frac{\text{Vol } B}{\text{Vol } A}(100 - F)$, which is implicit in the value of the adjusted sludge assay. This quantity is real and positive for all values of F and core recovery less than 100. Therefore the true core factor is always less than F except when F is equal to 100.

If sludge recovery is 100 pct, Eq. 3 can be further simplified as follows:

Let F = percentage of core recovered.

Let Vol $A = V_{dh}$ (100 Pct — Pct CR) where V_{dh} is the total volume of the sampled interval and let Vol $B = (V_{dh} - V_c)$ Pct CR where V_c is the core volume in the sampled interval at 100 pct core recovery. Then combined grade =

$$\frac{CA \text{ Pct } CR \dfrac{V_c}{V_{dh}} + \text{Assay 1, 100 Pct} - \text{Pct } CR \dfrac{V_c}{V_{dh}}}{100 \text{ Pct}} \quad [4]$$

Eq. 4 shows that when sludge recovery is 100 pct the laboratory sludge assay receives significant weight in the Chuquicamata method, even at 100 pct core recovery. The maximum weight assigned to the laboratory sludge assay depends on drillhole size, as follows:

Drillhole Size	Sludge Weighting Factor at 100 Pct Core Recovery, Pct
EX	64.5
AX	64.0
BX	51.9
NX	48.8

Eq. 4, with suitable changes in symbology, is identical to Royce's formula 8,* which is a statement of the Longyear or relative volume method of combining core and sludge assays.

If Mr. Waterman's assumption 3 is of paramount concern to the geologist, the Royce method (for core recoveries of 60 pct and above) or a method employing the percentage of core recovered as a core weighting factor are the only recognized methods known to the writer which achieve the desired result. A modification of the latter method embodying Mr. Waterman's assumptions 1 and 2 would result from applying the factors from Fig. 3 directly to the laboratory core and sludge assays.

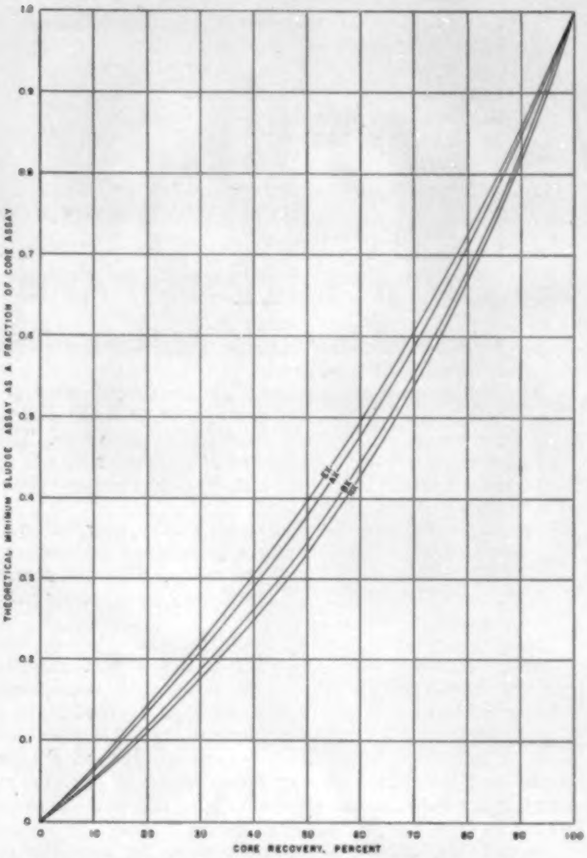


Fig. 9—Graph of theoretical minimum sludge assay for a given drillhole size, core recovery, and core assay. Based on nominal hole and core diameters.

If the Longyear method with the Chuquicamata modification is considered desirable, use of the factors in Table III (accompanying this discussion) for combining laboratory core and sludge assays (as distinct from the factors in Mr. Waterman's Fig. 3, which are applied to core and adjusted sludge assays) will produce results identical to those of the Chuquicamata method and calculation of the adjusted sludge assay is eliminated. The factors in Table III are calculated from Eq. 3. Separate tables would be required for each drill size. It is interesting to note that the rate at which the laboratory sludge assay weight decreases with decreasing sludge recovery in Table III does not follow the geometric progression defined by Mr. Waterman. The actual rate of decrease lies between the geometric and arithmetic (linear) rates, as might be expected on the basis of Eq. 3. Proof of this statement is not included here, but its truth can easily be demonstrated by comparison of two sets of factors, one calculated by using Eq. 3 (the Chuquicamata method) and the other by applying the geometric progression formula to Longyear values (representing strict conformity with Mr. Waterman's first assumption).

Mr. Waterman states on page 58, "The weighting to assign sludge samples . . . should decrease at a faster rate than the decrease in percentage return." In Fig. 3 the opposite seems to be true in the region of high sludge recoveries. The largest rate of decrease in adjusted sludge assay factor with respect to sludge recovery occurs in the region where sludge recovery is relatively low. In any case, the suggestion concerning geometric discounting of the sludge assay is interesting and is applicable to any of the basic methods of combining core and sludge assays. However, the writer's experience leads him to believe that in uncased drillholes a combination of caving and incomplete flushing might well produce a sludge sample of theoretical maximum weight whose reliability was highly questionable. Mr. Waterman's reasoning concerning the decrease in sludge sample reliability with decrease in sludge recovery seems most applicable when casing is advanced to the bottom of the drillhole and sealed following each sample run.

Mr. Waterman points out the existence of a theoretical minimum sludge assay. In Eq. 1, it is obvious that the adjusted sludge assay cannot be negative. The limiting condition is

$$\frac{\text{Vol } A + B}{\text{Vol } A} \cdot \text{Assay } 1 = \frac{\text{Vol } B}{\text{Vol } A} \cdot \text{Core Assay} \quad [5]$$

Fig. 9, accompanying this discussion, provides a simple means of evaluating this relationship. Sludge assays above the minimum value are not necessarily representative, but assays below the minimum definitely are not. In iron ore exploration, the target ores have tenors approaching 100 pct ore mineral (approximately 70 pct iron). Therefore, a theoretical maximum sludge

Table III. Geometric Combining Chart, for BX Core, for Laboratory Core and Sludge Assays Producing the Same Results as the Chuquicamata Method

Core Recovered, Pct	Sludge Recovered, Pct: 100	98	96	94	92	90	88	86	84	82	80
100*											
98	47.1 52.9	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0
96	46.2 53.8	73.1 26.9	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0
94	45.2 54.8	63.5 36.5	81.7 18.3	100 0	100 0	100 0	100 0	100 0	100 0	100 0	100 0
92	44.3 55.7	58.2 41.8	72.1 27.9	86.1 13.9	100 0	100 0	100 0	100 0	100 0	100 0	100 0
90	43.3 56.7	54.6 45.4	66.0 34.0	77.3 22.7	88.7 11.3	100 0	100 0	100 0	100 0	100 0	100 0
88	42.3 57.7	51.9 48.1	61.5 38.5	71.1 28.9	80.8 19.2	90.4 9.6	100 0	100 0	100 0	100 0	100 0
86	41.4 58.6	49.7 50.3	58.1 41.9	66.5 33.5	74.9 25.1	83.2 16.8	91.6 8.4	100 0	100 0	100 0	100 0
84	40.4 59.6	47.9 52.1	55.4 44.6	62.8 37.2	70.2 29.8	77.7 22.3	85.1 14.9	92.6 7.4	100 0	100 0	100 0
82	39.4 60.6	46.2 53.8	53.0 47.0	59.7 40.3	66.4 33.6	73.1 26.9	79.8 20.2	86.6 13.4	93.3 6.7	100 0	100 0
80	38.4 61.6	44.6 55.4	50.7 49.3	56.9 43.1	60.0 40.0	66.1 33.9	72.3 27.7	78.4 21.6	87.7 12.3	93.8 6.2	100 0

* Factors for 100 pct core recovery are meaningless if sludge is not contaminated because core and sludge assays must be identical. If core and sludge assays are not identical, it seems reasonable to rely on the core assay only.

assay exists that may be of value in determining iron ore sludge sample reliability.

The best test of any method of combining core and sludge assays is made by comparing combined assays with grade. However, the examining geologist often is required to evaluate properties prior to mine development and make recommendations on the basis of drilling data. Agreement seems general among geologists that sludge should receive progressively less weight as core recovery increases and should receive no weight when core recovery is 100 pct. The Royce method seems preferable to the Longyear-Chuquicamata method as a means of obtaining the combined assay. The combined grade then can be evaluated subjectively by considering core and sludge recoveries, casing position, physical characteristics of the rock penetrated—in other words, by exercising geological judgment. A combined grade never should stand alone but should be accompanied by a record of all data which bear on its validity.

Glenn C. Waterman *(author's reply)*—Mr. Strong, in general, agrees with the three basic assumptions that are the fundamentals of the Chuquicamata method. There cannot be serious disagreement with the principle that sludge samples lose reliability as sludge recovery drops. Secondly, in most cases, sludge samples are less reliable than core samples and it follows that when sludge recovery is less than core recovery the sludge sample should not be combined with the core sample to establish the grade of the run. And it should be recognized that any core sample is a truly representative sample of its percentage of a run.

It should be pointed out that the most important aspects of the Chuquicamata method are a reduction of sludge sample weighting as sludge recovery drops, and the use of the proposed combining weights for core and sludge samples at any recovery percentages. The adjustment of a sludge sample so that sludge grade represents only unrecovered core is a refinement we consider useful in the attempt to achieve a more accurate value for the sludge.

Mr. Strong's mathematical equations indicate, to him, that when a sludge sample is adjusted the core does not finally receive a weighting at least equal to core recovery percentage. For this reason he believes the entire Chuqui method is identical to the Longyear or relative volume combining method. Mr. Strong's conclusions, if accepted, are only applicable if the sludge sample is adjusted. If the sludge is not adjusted, the more important aspects of the Chuqui system offer a combining method that is markedly different from the Longyear system.

On a drilling job when 100 pct recovered core gives a representative sample of the ground tested, then sludge peripheral to this core has a similar grade. It follows that sludge peripheral to any recovered core has a grade similar to the core grade. This means we can use such sludge grade in an analysis of core and sludge combining percentages. Thus, I wish to point out that Strong's Table III does not give actual combining percentages of the core grade and laboratory sludge assay because the latter already has included in it a certain percentage of grade which is accepted as being identical to core grade. The following example will illustrate this.

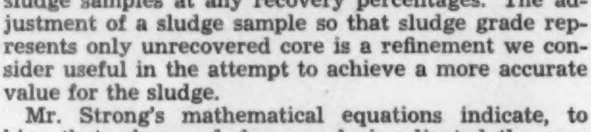


Fig. 10, shown above, employs the same nomenclature. Assume the following:

1) BX hole.
2) Core recovery is 80 pct, or 80 units (of core grade).
3) Lost core is 20 pct, or 20 units.
4) Sludge around recovered core is 80 units (of core grade).
5) Sludge around lost core is 20 units.
6) Total volume of core and sludge is 200 units.
7) Then the laboratory sludge assay is made up as follows:

(a) Lost core	20 units
(b) Sludge peripheral to lost core	20 units
	40 units of lost core grade
(c) Sludge peripheral to recovered core	80 units of core grade
	120 units

8) Thus the laboratory sludge assay contains 66 pct or 80 units of core grade.
9) The ground represented by recovered core receives a weighting percentage of 80 units due to core assay and 80 units due to sludge grade. The core interval thus receives 160 units or 80 pct of total grade, a figure equal to core recovery percentage.
10) Strong's Table III combines a laboratory sludge assay, which contains an important percentage of core grade, with a core assay. The net result is that core receives a weighting equal to its percentage recovery.

Exception to the above example may be taken on the grounds that the sludge sample is not a core sample and we should not include in the weighting percentage assignable to core grade any percentage derived from a sludge sample. But we are considering total percentages of combined grade due to core *grade* and sludge *grade* and the basis of any adjustment of the sludge assay is the assumption (correct) that the portion peripheral to core has an *identical* grade.

Should Mr. Strong's conclusions as to core-sludge weighting percentages resulting from sludge adjustment prove the more acceptable, I suggest that the adjustment step be eliminated, with the core and sludge assays being combined according to recovery percentages as originally described. Mr. Strong does not have serious criticism of this more important phase of the combining method.

Mr. Strong suggests the Royce method[a] is preferable to the Chuqui method. If we accept the suggestions that sludge samples lose reliability as recovery drops and the core sample should always receive a minimum weighting equal to core recovery percentage, then the Royce method is illogical; it underweights core except at 100 pct recovery and sludge weighting is not affected by sludge recovery. In addition the Royce method assigns core weighting percentages which may vary according to length of run, a function that should not enter into any combining method. The following example will illustrate this. Assume a 60 in. run with 50 pct recovery. Royce tables weight the core at 25 pct (less than recovery percentage) and sludge 75 pct. Consider the identical 60 in. length was drilled with *two* 30 in. runs, core recovery being 100 pct for the first 30 in. and 0 pct for the second 30 in. The Royce method would weight the first run at 100 pct core and 0 pct sludge and the second at 0 pct core and 100 pct sludge. In the first case the 60 in. run gives core a 25 pct core weight; in the second example the average of the two 30 in. runs weights core 50 pct.

Any combining method is subject to some criticism because innumerable variations in drill technique, core size, recovery percentages, and distribution of valuable mineralization in the ground require on-the-job modifications. However, I suggest the Chuqui method is based on a common sense appraisal of the worth of core and sludge at variable recovery percentages and offers a sensible approach to the complex problem of establishing an accurate drill grade.

Reference

[a] Josiah Royce: A New Method of Weighting Core and Cuttings in Diamond Drilling. *AIME Trans.*, 1949, vol. 184, pp. 358-360.

aime news

William Wallace Mein, Jr., to Speak At Black Hills Regional Meeting

The MGGD Fall Meeting and Industrial Minerals Div. Regional Meeting to be held at Rapid City, S. D., October 2 to 5 has secured William Wallace Mein, Jr. AIME Vice President, as banquet speaker. Mr. Mein, a third generation mining man, is president of Calaveras Cement Co. and Bishop Oil Co., both of San Francisco. It has also been arranged to have the Honorable Joe Foss, Governor of South Dakota, as the principal welcoming luncheon speaker.

HON. JOE FOSS

WILLIAM W. MEIN, JR.

The Woman's Auxiliary has its plans completed. The ladies of the Lead area have planned a luncheon and scenic drive for Sunday when the men are touring the underground operations at Homestake. The Rapid City ladies have scheduled two luncheons and outings, one to Mt. Rushmore with luncheon at Powder House Lodge, and the second to Ellsworth Air Force Base with luncheon at the Officers' Club.

Industrial Minerals Div.

Caterpillar shovel is stripping beds near Kings Mountain, N. C., one of the field trip areas to be visited as part of the 3-day Industrial Minerals Fall Meeting. This year division meets at Charlotte, N. C., October 27 to 29.

Coal Div.

18th Annual AIME-ASME Joint Solid Fuels Conference, program on page 878.

Time: October 19 to 21
Place: Neil House, Columbus, Ohio.

Rocky Mountain Minerals Conference Set for October 6 to 8

For program see pages 797-8 September MINING ENGINEERING

Busy Utah committeemen were caught in this picture taken at the Kennecott Research Center.

1st Row, left to right: Glen A. Burt, Secretary, Utah Section; Norman Weiss, Conference Co-Chairman; Neil Plummer, Vice-Chairman, Utah Section; J. M. Ehrhorn, Chairman, Utah Section; R. C. Cole, Conference Co-Chairman.

2nd Row, left to right: C. P. Mott, Chairman, Meeting Rooms and Equipment; Raymond Thompson, Chairman, Extractive Metallurgy, Non-ferrous; I. K. Hearn, Chairman, Cocktail Buffet; S. I. Bowditch, Chairman, Mining and Geology; V. L. Stevens, Publicity Chairman; W. F. Rappold, Chairman, Industrial Minerals.

3rd Row, left to right: I. G. Pickering, Chairman, Hotel Reservations; R. E. O'Brien, Field Secretary, AIME; K. A. Lehner, Chairman, Entertainment; E. K. Olson, Chairman, Field Trips.

Absent when picture was taken: Grant Schaumburg, Co-Chairman, Field Trips; Ewald Kipp, Co-Chairman, Cocktail Buffet; R. W. Lawson, Luncheon Chairman; Max DuBois, Co-Chairman, Entertainment; Leonard Tofft, Chairman, Ferrous Metallurgy.

18th AIME-ASME JOINT SOLID FUELS CONFERENCE

October 19 to 21

Neil House, Columbus, Ohio

Program

WEDNESDAY, OCTOBER 19

8:30 am

Registration

Registration desk will be open October 18 at 3:00 pm for early arrivals.

Technical Session

10:00 am

Co-Chairmen: C. L. Potter, Manager, Coal and Coke Research Div., Jones & Laughlin Steel Corp., Pittsburgh; and Charles H. Marks, Project Engineer, Bituminous Coal Research Inc., Columbus, Ohio.

Coal Reserves of the United States for Future Use, by Clayton G. Ball, President, Paul Weir Co., Chicago.

Petrographic Methods for Application to Solid Fuels of the Future, by James M. Schopf, Supervising Geologist, Coal Geology Laboratory, USGS, Columbus, Ohio.

The Relation of Petrographic Structure to Utilization of Solid Fuels of the Future, by A. T. Cross, Coal Geologist, Paleobotanist, West Virginia Geological Survey, and Norman Schapiro, Graduate Student, West Virginia University, Morganstown, W. Va.

Luncheon

12:30 pm

Speakers: David R. Mitchell, Secretary-Treasurer, Coal Div., AIME, and Carroll F. Hardy, Chairman, Fuels Div., ASME.

Technical Session

2:00 pm

Co-Chairmen: W. S. Major, Project Engineer, Machinery Div., Dravo Corp., Pittsburgh; and Frank G. Smith, President, The Sunday Creek Coal Co., Columbus, Ohio.

The Need and the Opportunities for Fuel Techniques in the Coal Industry, by T. S. Spicer, Professor, Fuel Technology, Pennsylvania State University, University Park.

Future Trends in Stoker Design, by Earle C. Miller, Research Engineer, Riley Stoker Corp., Worcester.

Trends in Coal Handling for Electric Power Stations, illustrated with a motion picture, *From Mine to Plant,* by Howard E. Nelson, Manager, Conveyor Engineering, The Jeffrey Mfg. Co., Columbus, Ohio.

LADIES' ACTIVITIES

October 19

8:30 a.m.	Registration, Neil House
10:00 a.m.	Coffee hour, Neil House
12:30 p.m.	Luncheon and bridge at Scioto Country Club
6:30 p.m.	Cocktail hour, Neil House
7:00 p.m.	Banquet, Neil House

October 20

1:00 p.m.	Luncheon at Maramor Restaurant
2:30 p.m.	Conducted tour of Columbus Art Gallery

Banquet

7:00 pm

Toastmaster: Elmer R. Kaiser, Director of Research, American Society of Heating and Air-Conditioning Engineers Inc., Cleveland.

Speaker: L. C. Campbell, President, National Coal Assn., Washington, D. C.

THURSDAY, OCTOBER 20

Technical Session

9:30 am

Co-Chairmen: H. F. Yancey, Chief, Div. of Solid Fuels Technology, Region I, USBM, Seattle; and Walter L. Hartman, Assistant Director, Physical Plant, Ohio State University, Columbus.

Coal Preparation at J&L Vesta Mines Showing Trend of Future Coal Washers, by J. A. Glunt, Steel Works Metallurgist, Cleveland Works, and J. R. Dawson, Chief Chemist, Vesta-Shanopin Coal Div., Jones & Laughlin Steel Corp.

Solid Fuels and the Dwight-Lloyd Sintering Process, by Harold E. Rowen, General Manager, Dwight-Lloyd Div., McDowell Co. Inc., Cleveland.

Pulverizing Lignite in a Bowl Mill, by R. C. Ellman, Supervising Chemical Engineer, Preparation Section, Charles R. Robertson Lignite Research Laboratory, USBM, Grand Forks, N. Dak.

High-Moisture Lignite as a Fuel for Steam Generation Present and Future, by R. L. Sutherland, Research Consultant, Truax-Traer Coal Co., Chicago.

Percy Nicholls Award Luncheon Meeting

12:30 pm

Presentation of Percy Nicholls Award for 1955

Recipient: Ralph M. Hardgrove

Presenter: Elmer R. Kaiser

Speaker: Ralph A. Sherman, Technical Director, Battelle Memorial Institute

Technical Session

2:00 pm

Co-Chairmen: C. H. Sawyer, Research Engineer, Coal Div., Eastern Gas & Fuel Assoc., Pittsburgh, and John H. Melvin, Chief, Div. of Geological Survey, Ohio Dept. of Natural Resources, Columbus, Ohio.

Future of Synthetic Liquid and Gaseous Fuels, by H. R. Batchelder, Consulting Chemical Engineer, and Harlan W. Nelson, Chief, Fuels Technology Div., Battelle Memorial Institute, Columbus, Ohio.

Navy Policy of Designing for Dual Fuel Firing in Shore Station Steam Plants, by Leroy F. Deming, Head, Power Generating Section, Bureau of Yards and Docks, U. S. Navy.

FRIDAY, OCTOBER 21

Field trips can be arranged to Columbus plants and laboratories internationally known for their work on solid fuels. Possible points of interest include: Battelle Memorial Institute; Bituminous Coal Research Inc.; Jeffrey Mfg. Co.; Ohio State University; and USGS offices.

Arnold Buzzalini Is Chosen As New Mining Branch Secretary

After several months' search, Arnold Buzzalini has been engaged as the new Secretary for the Mining Branch of the AIME. Mr. Buzzalini

ARNOLD BUZZALINI

most recently has been manager and chief geologist of the Uranium Div., Pubco Development Inc., Albuquerque, N. M., where he will be working until he comes to the Institute. He has also been secretary of the New Mexico Geological Society and was chairman of the committee for its ninth annual meeting last May in Gallup, N. M.

Arnold, or "Buzz" as he is sometimes called, comes from a mining family. Mr. Buzzalini went to Syracuse University for his geology training, later doing graduate work at Johns Hopkins and Penn State. His college career was interrupted by a three-year stretch in the Air Force, principally in Alaska and the Yukon.

After completing his formal schooling he spent a year in geological work in the East and then went with Phillips Petroleum Co., Bartlesville, Okla., in 1951 as a staff geologist on exploration and development. Last year he joined the company's Strategic Minerals Div. and a few months ago joined the staff of his present employer. He has visited mines in the West, extending from Alaska and the Yukon to Pachuca in Mexico. His hobbies are hunting, fishing, pistol marksmanship, gem and mineral collecting and polishing, photography, skiing, and Boy Scout work. At college he got his letters in boxing, fencing, and rifle shooting, and received the 1942 Intramural Managers Medal. At this time he also became a Student Associate of the AIME. He has written several papers and articles, largely on geological subjects, some of which he has presented at society meetings.

E. H. Robie and Mr. Buzzalini plan to be at the Rapid City and Salt Lake City meetings of the AIME this fall and at the Mining Congress meeting in Las Vegas.

TRANSACTIONS SETS NEEDED

AIME headquarters has received requests from members helping establish technical schools abroad for assistance in locating complete or partial sets of Transactions volumes. If you have a set, or partial set, of AIME Transactions you wish to dispose of, please write to:

Editor, Mining Engineering
American Institute of Mining & Metallurgical Engineers Inc.
29 W. 39th Street
New York 18, N. Y.

MINING BRANCH MEMBERSHIP DRIVE

In preceding columns some mention was made of those conditions that face us in recruiting new members for the Institute. We have another problem of importance to all members also, that of keeping members who have joined our ranks on our rolls. At the time this column was written there were 22,910 members and 1890 student members.

On graduation, these 1890 student members are automatically transferred to Junior Membership. This transfer must, however, be accepted by these younger men, and they are, of course, liable for payment of annual dues as Junior Members for the year of their transfer. Only 70 pct or less of these younger men comply with these requisites and continue actively their membership in the Institute. In many cases the determining factor has been the indifference of other members. A show of interest in these men who are entering the fraternity would keep them interested in the Institute in transition years between college training and industry.

Losses are also prevalent among the Junior Members. On completing six years of Junior Membership they find their dues increased by $5.00 yearly, and at a certain age they are automatically transferred either to Associate Membership or full Membership. In both cases they become liable not only for increased dues but also for initiation fees. This is usually the critical period, as many of the Juniors find this increase in financial obligations somewhat onerous, all the more so in cases where the Junior Member has not been able to avail himself of the full advantages of the Institute. Members of the Sections should know these Junior Members and when this time of transition to full status comes due should show them the advantages of continued membership. Here too, a crucial responsibility lies on the shoulders of the members in the field rather than on officers of Sections, Divisions, and Branches.

Often delinquent dues create problems that lead to resignation of members. When they are faced with the payment of two years' dues, the burden becomes heavier still and many times this neglect results in just "giving it all up." If the reasons are justifiable, methods and means can be found to mitigate the problem.

Remember that the continued growth and good health of our Institute depends not only on acquiring new blood, but on keeping the present blood circulating in its veins. Every member can shoulder his share of this burden and keep our rolls growing each year.

*C. E. Golson**

** Vice Chairman, AIME National Membership Committee*

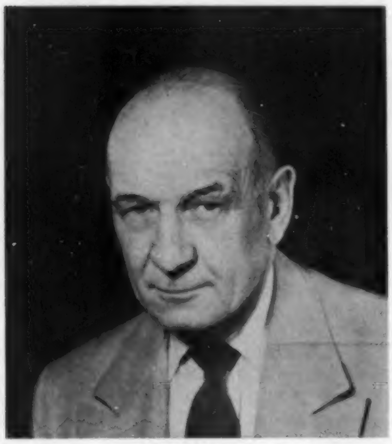
PERSONALS

Allen D. Kennedy is metallurgist in charge of flotation and milling research, Tennessee Copper Co., Copperhill, Tenn. He was research metallurgist, Cleveland-Cliffs Iron Co., Ishpeming, Mich., and had been with this company for the past five years.

Harold B. Ewoldt, vice president, Copper Range Co., Boston, and vice president and general manager of its subsidiary White Pine Copper Co., White Pine, Mich., has returned to Boston. Mr. Ewoldt is succeeded at White Pine by **H. Dodge Freeman.**

John A. Rassenfoss has been appointed manager, Manufacturing Research Laboratory, American Steel Foundries, Chicago. **C. G. Mickelson** and **P. J. Neff** are assistant managers.

Harold L. Gardner, mining engineer, International Minerals & Chemical Corp., Carlsbad, N. M., is now with Kerr-McGee Oil Industries Inc., Carlsbad.



J. F. MYERS

John F. Myers, consulting engineer, Greenwich, Conn., has joined Denver Equipment Co., Denver, as a consultant. After graduating from the Colorado School of Mines in 1913, Mr. Myers joined the Butte & Superior Copper Co., Black Rock mine. From there he went to American Zinc Co., Mascot, Tenn., and later to The New Jersey Zinc Co., Austinville, Va. He joined the Tennessee Copper Co. in 1926 and remained with them for 26 years, during which time his many interesting discoveries, developments, and experimental work led him closer to the work on comminution for which he is probably most widely known.

B. S. Dalton, maintenance superintendent, Kaiser Aluminum & Chemical Corp., Baton Rouge, La., is now at the company's home office in Oakland, Calif.

R. K. Comann, project engineer, Technical Div., Pabco Products Inc., Emeryville, Calif., is resident engineer for the new gypsum wallboard plant the company is building at Florence, Colo.

R. C. STEPHENSON

Robert C. Stephenson, Woodward & Dickerson Inc., Philadelphia, has been appointed executive director, American Geological Institute, Washington, D. C. From 1946 to 1952 Mr. Stephenson was assistant state geologist of Pennsylvania. He succeeds **Charles Hunt,** who is returning to the USGS.

P. V. G. Ford is now managing director, Sinai Mining Co. Ltd., Cairo, Egypt.

Charles M. Hillery, West Virginia Coal & Coke Corp., Omar, W. Va., is mining engineer, Victor Oolitic Stone Co., Bloomington, Ind.

P. J. Shenon and **R. P. Full,** mining geologists of Salt Lake City, have established a branch office of their firm in the Munro-Morrison Bldg., Grand Junction, Colo. **A. L. Payne** will be in charge of this office. Mr. Payne was associated with Shenon & Full for two years in Cuba and prior to that was with American Smelting & Refining Co. in South America and the Southwest.

Robert B. Hargraves, formerly geologist with Newmont Exploration Ltd., Jerome, Ariz., is in the Army and is stationed at Arlington, Va.

E. J. Perry, who was with Giant Yellowknife Gold Mines Ltd., Yellowknife, N. W. T., Canada, has accepted a position with Eldorado Mining & Refining Ltd., Beaverlodge Operation, Saskatchewan.

Felix C. Scanlon is with Creole Petroleum Corp., Tía Juana, Venezuela. Mr. Scanlon was graduated recently from South Dakota School of Mines, Rapid City.

R. A. Wyman, ore dressing engineer, Aluminium Laboratories Ltd., Arvida, Que., is flotation engineer, Dept. of Mines & Technical Surveys, Industrial Minerals Div., Ottawa. Mr. Wyman is secretary of the Industrial Minerals Div., Canadian Institute of Mining and Metallurgy, for 1955.

H. Michael Breza, formerly of the University of North Dakota, Grand Forks, is a lieutenant in the U. S. Army, Fort Riley, Kan.

Eugene W. Wheeler is a junior geologist with Andes Copper Mining Co., Potrerillos, Chile. Mr. Wheeler was with The Anaconda Co., Butte, Mont.

Harold E. Lee, general superintendent, Bunker Hill smelter, Kellogg, Idaho, **Wallace G. Woolf,** manager, Sullivan Mining Co., Kellogg, and **H. P. Lawrence,** vice president, Northwest Lead Co., Seattle, have been appointed to the board of directors of the Northwest Lead Co.

Arnold H. Miller of New York has been appointed consulting engineer and a member of the board of directors, Cía. Nacional Cubana de Minas S. A., and is now doing work on the company's Cuban properties.

Frank W. Glaser has been appointed general manager, Alloy Precision Castings Co., Cleveland. He will continue to be vice president.

LOUIS BUCHMAN

Louis Buchman, former vice president and director, Kennecott Copper Corp., Salt Lake City, has been elected to the board of directors, Uranium Corp. of America. Mr. Buchman was graduated from Michigan College of Mines in 1907 with B.S. and E.M. degrees. In 1949 he received an honorary degree of Doctor of Engineering from Michigan College of Mining and Technology. In 1914 Mr. Buchman joined Kennecott as assistant mine assayer. He became vice president and director in 1952. Mr. Buchman retired from Kennecott in 1953.

J. P. Dempsey, Cramet Inc., Chattanooga, Tenn., has accepted the position of project engineer, Central Farmers Fertilizer Co., Georgetown, Idaho.

Frank Coolbaugh has been elected a director of Climax Molybdenum Co., Climax, Colo. Mr. Coolbaugh joined Climax in 1933 and is now vice president, Western Operations. He is also president and a director of Climax Uranium Co., Grand Junction, Colo.

Neal M. Muir, formerly of the U. S. Bureau of Mines Spokane office, now has his headquarters at the La Court Hotel, Grand Junction, Colo. Since January he has been engaged in mine examination work in Colorado, Utah, and Arizona and has also been in New Mexico and Texas examining uranium prospects.

M. M. Harcourt, who was mining engineer, U. S. Bureau of Mines, Salt Lake City, is mine superintendent, Haile Mines Inc., Hillsboro, N. M.

Sergei E. Zelenkov has been made assistant general manager, northwestern mining dept., American Smelting & Refining Co., Wallace, Idaho. Mr. Zelenkov has been associated with Asarco since 1936. In 1945 he became mine superintendent, and later general superintendent of mines, Kokomo Unit in Colorado. He was transferred to Lima, Peru, in 1952 as manager of operations of the Northern Peru Mining & Smelting Co.

R. E. Shinkoskey, assistant manager, southwestern dept., American Smelting & Refining Co., El Paso, Texas, has been transferred to Tacoma, Wash.

Robert G. Reeves, geologist, USGS, Reno, Nev., has been assigned to Defense Minerals Exploration work, USGS Pacific Coast Center, Menlo Park, Calif.

W. Julian Parton, formerly president of Lehigh Navigation Coal Co., and more recently president and chairman of the board, Panther Valley Coal Co. Inc., Lansford, Pa., has entered consulting work. One of his current assignments concerns the manufacture of coke from anthracite. In this connection, Mr. Parton is studying present methods in the U. S. and abroad and recently returned from Peru. In 1939 he received his M.S. in mining engineering from the University of Washington, where he held a research fellowship awarded by the USBM and the university. Mr. Parton was awarded an E.M. degree by Pennsylvania State University in 1944.

Mortimer F. Sayre, professor of applied mechanics and chairman, dept. of mechanical engineering, Union College, Schenectady, N. Y., is retiring. Mr. Sayre will keep up his consulting and other connections at 1169 Parkwood Blvd., Schenectady 8.

Robert S. Burton is mine superintendent, American Smelting & Refining Co., Patagonia, Ariz.

R. H. Kimball, Jr., Cerro de Pasco Corp., Arequipa, Peru, is now with Nationes Unidas, La Paz, Bolivia.

M. A. Jackson, chief chemist, Anaconda's Great Falls, Mont., reduction dept., has been promoted to research engineer for the department.

G. C. DYAR

Grosvenor C. Dyar has been appointed general superintendent of mines, Alabama By-Products Corp., Birmingham. Prior to joining Alabama By-Products in February 1953, as superintendent of its Maxine mine, he was operating vice president, Stith Coal Co. Mr. Dyar is a graduate of the University of Alabama.

Robert D. Whitmer, W. G. Duncan Coal Co., Greenville, Ky., is mine engineer, DeKoven Coal Mining Co., Sturgis, Ky.

G. A. Beattie, Lake George Mines Pty. Ltd., Captain's Flat, N. S. W., Australia, has accepted a position as underground manager, Radium Hill Project, Radium Hill, South Australia.

John J. Reed is head mine research engineer, St. Joseph Lead Co., Bonne Terre, Mo. Mr. Reed was formerly lecturer in mining and a graduate student at the University of California, Berkeley. He received a Ph.D. in mining engineering from the university in June.

Eugene Larrabure, mining engineer, Herramientas Thor de Mexico, Mexico, D. F., is now service engineer, Thor Power Tool Co., Lima, Peru.

A. E. Jones of Wakefield, Yorks., England, has been appointed mine manager, Gasswater mine, Anglo Austral Mines Ltd., Scotland.

J. R. Van Pelt will be one of the principal speakers October 11 at the 50th anniversary of the Illinois State Geological Survey, University of Illinois, Urbana. Mr. Van Pelt is president, Montana School of Mines, and director, Montana Bureau of Mines & Geology.

William L. Walsh has been elected president, Quebec Iron & Titanium Corp., New York, which is two thirds owned by Kennecott Copper Corp. and one third by The New Jersey Zinc Co. Mr. Walsh joined Kennecott in April of this year as assistant to the president in the field of the corporation's titanium interests.

E. H. CRABTREE, JR.

Edwin H. Crabtree, Jr., deputy manager, AEC Operations Office, Grand Junction, Colo., has been appointed director, Colorado School of Mines Research Foundation Inc., Golden. Mr. Crabtree was graduated from the Colorado School of Mines in 1927. He has more than 27 years' experience in the mining and metallurgical industries, including 19 years with the Eagle-Picher Co. From 1940 to 1943 he was metallurgist for the Arizona Bureau of Mines, University of Arizona. In 1952 Mr. Crabtree received the AIME Mill Man of Distinction Award. He has written several technical papers for the AIME.

Jay C. Dotson is assistant professor, mining engineering, College of Mines, University of Idaho, Moscow.

Clarence A. Weekley, mines dept., Soriano y Cía, Manila, P. I., is in the U. S. on a combined business and vacation trip. Before returning to the Philippines early in October he will have visited Michigan, Wisconsin, and Minnesota, also various mining operations in Colorado, Utah, and Nevada, and some of the large copper properties in Arizona and New Mexico.

M. John Bernstein has joined the Exploration & Development Div., Climax Molybdenum Co., Western Operations, Denver. He was product planning coordinator, Consolidated Engineering Corp., Pasadena, Calif., and was with this firm for three years.

Frank C. Pickard, head, Mining Div., Gregg Car Co. Ltd., Brussels, was in the New York office during August. Mr. Pickard, who recently returned to Belgium from a trip through Africa, plans to travel extensively in Central and South America.

E. D. Gardner, chief engineer, U. S. Bureau of Mines, Washington, D. C., has undertaken to continue studies on the sulphur industry in Sicily. These studies were started by **Charles Will Wright,** vice president, World Mining Consultants Inc., New York, before he met with an automobile accident in Virginia last May.

J. Edward Berg, general manager, northwestern mining dept., American Smelting & Refining Co., Wallace, Idaho, has retired. Mr. Berg was graduated from the University of Washington and worked for some years on mining properties in Alaska and Idaho. In 1923 he joined Federal Mining & Smelting Co., which has since been merged with Asarco. Mr. Berg is succeeded by **Joseph Charles Kieffer.** After receiving a B.S. degree in metallurgical engineering at Washington State College, Mr. Kieffer started as a mucker for Climax Molybdenum Co., Colo. In 1937 he joined the Cerro de Pasco Copper Corp. in Peru. He returned to the U. S. in 1940 and worked in Idaho for the Sink & Float Corp. Prior to joining Asarco in 1952 Mr. Kieffer was general manager of Spokane-Idaho Mining Co.

George D. Grayer, Bucyrus-Erie Co., Kansas City district office, has been transferred to the main office in South Milwaukee, Wis.

H. B. Charmbury is head, mineral preparation dept., Pennsylvania State University, University Park.

Harold W. Bishop, formerly chief engineer, Consolidated Coppermines Corp., Kimberly, Nev., recently accepted the position of chief engineer, Ray Mines Div., Kennecott Copper Corp., Ray, Ariz.

Thomas E. Ban has been appointed director of research for the McDowell Co. Inc., Cleveland. Mr. Ban was formerly chemical engineer, research laboratory, Cleveland-Cliffs Iron Co., Ishpeming, Mich.

Carroll F. Hardy, chief engineer, Appalachian Coals Inc., Cincinnati, is head of new department of sales engineering, National Coal Assn., which will supplant some of the work previously performed by NCA's coal heating service. Mr. Hardy has been associated with the coal industry some 18 years and for most of that time has been with Appalachian Coals Inc.

Carl F. Gommel is chemical plant superintendent, Tungsten Mining Corp., Henderson, N. C.

Richard C. Wells, formerly controller of Freeport Sulphur Co., is president of National Potash Co., jointly owned by Freeport and Pittsburgh Consolidation Coal Co. **Robert D. Hill** succeeds Mr. Wells as controller of Freeport Sulphur Co.

B. F. Witmer has joined the engineering dept., Traylor Eng. & Mfg. Co., Allentown, Pa. Mr. Witmer came to Traylor from Vulcan Iron Works, Wilkes-Barre, Pa., where he was manager, cement equipment sales. He was graduated from Lehigh University and the University of Pennsylvania.

K. M. DEWAR

K. M. Dewar has been appointed manager, Mining Div., R. M. Way & Co., Toronto. Mr. Dewar has had wide experience in underground development and mining operations and will act as consultant to the company's clients in this field.

Anthony Anable has resigned from Dorr-Oliver Inc., Stamford, Conn., and is associated with the United Fund of Stamford Inc. as director of public relations.

David Swan has been appointed director of research, Metals Research Laboratories, Electro Metallurgical Co., a Division of Union Carbide & Carbon Corp., Niagara Falls, N. Y. Mr. Swan has been with UC&C since 1946. He will continue to be located at Niagara Falls.

George Radomsky is with Intermountain Chemical Co., Food Machinery & Chemical Corp., West Vaco, Wyo. He was with North American Refractories Co., Curwensville, Pa.

James F. Bell, Portland Gas & Coke Co., Portland, Ore., has been appointed executive vice president. Mr. Bell joined Gasco in 1946 as assistant to the president and has been a vice president since 1949 and a member of the board of directors since 1950. He is a graduate of Stanford University and studied in Germany for two years at the University of Munich. Mr. Bell is a director of Pacific Coast Gas Assn. and also a director of the Raw Materials Survey.

Basil Kamener, assistant mining engineer, The Anaconda Co., Butte, Mont., has joined the Board of Water Supply of New York City, as junior civil engineer.

Florence Harris, A. C. Fieldner, E. D. Gardner, J. H. Hedges, and **J. D. Secrest,** all of the U. S. Bureau of Mines, have retired or will retire in the near future. They were guests of honor at a dinner held at the Sheraton-Park Hotel, Washington, D. C., on August 23. Assistant Secretary of the Interior **Felix Wormser** was the toastmaster and appropriate gift presentations were made.

Andrew T. Sweet is director of a new consulting engineering organization known as Sweet's Engineering Consultants, at E. 38th Ave. & Elm St., Denver. The firm will specialize in consulting geological service, radioactive surveying, assays, mine and prospect evaluations, and laboratory and library research. A former professor, director of research, and head of the metallurgy dept., Michigan College of Mines, Mr. Sweet served recently as chief metallurgist for the Colorado field office of the USBM in Denver. **Walt Burleson,** a vice president of Colorado Mining Assn., will direct the Mining Div. in the new firm. Mr. Burleson, formerly chief, USBM at Spokane and Seattle, has been associated with Magma Copper, Garfield Mines, and Antoro Mines. **Mohammed Azhar,** Near Eastern geologist, will join the geological section of the firm. His doctor's thesis on the Salida area is being published by the U. S. Geological Survey.

Henry E. Brown of Albuquerque, N. M., has joined Lepanto Consolidated Mining Co., Lepanto, Mountain Province, P. I.

Robert W. MacCannon, who was assistant mining engineer, mining dept., Colorado Fuel & Iron Corp., Pueblo, Colo., is assistant chief engineer at the company's Sunrise mine, Sunrise, Wyo.

Paul L. Jones, Rico Argentine Mining Co., Rico, Colo., has accepted a position as mining engineer with Homestake Mining Co., Moab, Utah.

D. L. DAVIS

Dudley L. Davis, assistant chief, Salt Lake City Exploration Branch, Div. of Raw Materials, AEC, was awarded the degree of Engineer of Mines by the Mackay School of Mines, Reno, Nev. After graduating from Mackay with a B.S. in mining engineering in 1941, Mr. Davis worked for International Smelting & Refining Co., Copper Canyon, Nev., and for The Anaconda Co., at Butte, Mont., the North Lily mine, Eureka, Utah, and Darwin Mines Div. He went to Salt Lake City in 1954.

A. C. FIELDNER

Arno C. Fieldner, staff advisor, U. S. Bureau of Mines, Washington, D. C., has retired after more than 48 years of outstanding Government service. Mr. Fieldner was graduated from Ohio State University and after a brief period in private industry joined the Federal Geological Survey at Pittsburgh in 1907. He transferred to the USBM on its creation in 1910. In 1927 he went to Washington as supervisor of Experiment Stations and became chief of the Bureau's Technologic Branch in 1936. In 1942 he was made chief of the Fuels and Explosives Service, now the Divisions of Solid Fuel, and Petroleum and Natural Gas. Mr. Fieldner was chief fuels technologist from 1950 to 1954, when he was appointed staff advisor. He is the author of more than 400 articles, reports and technical publications on fuel testing and research. Mr. Fieldner has received several awards for scientific achievement including the Lamme and Joseph Sullivant medals from Ohio State University; the AIME and ASME Percy Nicholls Award in 1946; the Melchett Medal in 1942, conferred by the Institute of Fuels of Great Britain; and in 1949 the Distinguished Service Medal of the Dept. of the Interior.

R. H. Willey, general superintendent, Philippine Iron Mines Inc., Panganiban, Camarines Norte, P. I., has resigned and plans to travel west from the Philippines, spending some time in Europe and the U. S. observing mining methods and ore beneficiation. He expects to be in Kaysville, Utah, by the end of the year.

Glenn Waterman, mining geologist, Chile Exploration Co., Chuquicamata, Chile, is now a field geologist, Exploration Div., The Anaconda Co., Salt Lake City.

Edward W. R. Butcher, chief mine engineer, Northern Ore Mines of the Republic Steel Corp., has retired. Mr. Butcher started with Republic, when it was known as the Republic Iron & Steel Co., as a mining engineer at Gilbert, Minn., on the Mesabi range in 1909.

MEMBERSHIP

Proposed for Membership
Mining Branch, AIME

Total AIME membership on July 31, 1955 was 23,073; in addition 1918 Student Associates were enrolled.

ADMISSIONS COMMITTEE

P. D. Wilson, Chairman; F. A. Ayer, Vice-Chairman; A. C. Brinker, R. H. Dickson, T. D. Jones, F. T. Hanson, Sidney Rolle; O. B. J. Fraser, F. T. Sisco, Frank T. Weems, R. L. Ziegfield, R. B. Caples, F. W. McQuiston, Jr., A. R. Lytle, H. R. Wheeler, L. P. Warriner, J. H. Scaff.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; A, Associate Member; S, Student Associate.

Alabama
Birmingham—Cahill, George E. (R. C/S—S-M)
Arizona
Ray—Wertz, Jacques B. (M)
Tucson—Garmoe, Walter J. (J)
California
Downey—Records, Henry H. (M)
Los Angeles—MacAfee, Donald B. (R. M)
Ontario—Buchholtz, Herbert F. (C/S—J-M)
Palo Alto—Downey, J. Ward (R. M)
Riverside—Dafoe, Eric W. (J)
Colorado
Denver—Ahlborg, William T. (C/S—A-M)
Denver—DeHuff, William H. (A)
Grand Junction—Havins, Thomas R., Jr. (R. C/S—S-M)
Gunnison—Wells, Alonzo M. (R. C/S—J-M)
Florida
Lakeland—Follansbee, James W. (J)
Idaho
Montpelier—Gaynor, Thomas E. (R. C/S—S-M)
Illinois
Argo—Hibbeln, Raymond J. (J)
Kentucky
Jenkins—Zegeer, David A. (R. C/S—J-M)
Pikeville—Roller, Raymond F. (M)
Louisiana
New Orleans—House, Richard D (J)
Massachusetts
North Easton—Utter, Joseph L. (M)
Minnesota
Duluth—Healy, John H. (M)
Missouri
Bonne Terre—De Clue, Benjamin F., Jr. (M)
St. Louis—Hicks, Thomas A. (M)
Nevada
Las Vegas—MacDonald, John C. (M)
Reno—Anctil, Ralph J. (J)
New Jersey
Oakland—Adkins, Robert C. (R. A)
Westfield—Davis, George H. (A)
New Mexico
Lovington—Glossop, Robert L. (J)
New York
New York—Claus, Richard J. (J)
Star Lake—Taylor, Howard J. R. (M)
Ohio
Cleveland—McClurg, John (R. C/S—S-A)
Pennsylvania
Brookville—Nash, Edgar (M)
Dallas—Drake, George R. (A)
Dallas—Jennings, Frederick W. (A)
Kittanning—Griffin, John P. (R. C/S—S-A)
Pittsburgh—Dengler, Theodore J. (R. C/S—J-M)
Pittsburgh—Wilson, Robert W. (M)
Waymart—Schreckengost, Ernest D. (A)
South Dakota
Lead—Morcom, Lewis W. (M)
Tennessee
Knoxville—Pratt, Edgar M. (M)
Texas
Daingerfield—Curtice, David K. (J)
Daingerfield—Hughes, Martin J. (R. C/S—S-M)
Houston—Prince, Robert W. (R. M)
Wharton—Johnston, Robert H. (A)
Utah
Cedar City—Heaton, Norman I. (M)
Cedar City—Standifird, George B. (M)
Cedar City—Wahl, Roy L., Jr. (R. C/S—J-M)
Lark—Anderson, John W. (R. C/S—S-J)
Murray—Thompson, Mercer F. (R. C/S—J-M)
Salt Lake City—Currie, Robert (A)
Salt Lake City—Rising, Vernon K. (A)
Washington
Spokane—Bhacca, Norman S. (J)
Spokane—Hertel, MacNeil E. (R. C/S—J-M)
Wisconsin
Milwaukee—Hood, Kenneth O. (M)
Africa
East Africa, Tanganyika Territory, Mpanda-Sengel—Herwig, F. G. (J)
South Africa, Pretoria, Menlo Park—Hoffman, Daniel J. N. (M)
Australia
New South Wales, Broken Hill—Howell, Murray W. (M)
Brazil
Sao Paulo—Mattoso, Sylvio deQ. (J)
Colombia
Cali—Scardino, James J. (A)
El Bagre—Lusney, John E. (M)
England
London—Dzienisiewicz, Jan (M)
Malaya
Kampar—Aubert, Marcel P. (M)
Peru
Casapalca—Chrzanowski, Tadeusz (M)
Cerro de Pasco—Bautista, Felipe (M)
Lima—Mastrovich, John J. (M)
Lima—Smith, Julian D. (A)
Philippines
Lepanto—Smith, Donald A. (R. C/S—S-A)

OBITUARIES

Arthur Clemes (Member 1948) died suddenly Dec. 4, 1954. He was chief consulting metallurgist, New Consolidated Gold Fields Ltd., Johannesburg, South Africa. Mr. Clemes was born in England in 1903 and received a B.Sc. from Birmingham University in 1924. From 1925 to 1928 he was with Sub Nigel Ltd., Transvaal, and from 1928 to 1930 he was the metallurgist in charge, Lydenburg Platinum Areas Ltd., Transvaal. He was with East Geduld Mines Ltd. for four years before joining New

Necrology

Date of Election	Name	Date of Death
1930	Marcel Dupont	July 24, 1955
1940	H. E. Hall	July 8, 1955
1941	Morris F. Lacroix	July 29, 1955
1941	Martin C. Messner	May 31, 1955
1920	Harry A. Townsend	June 11, 1955
1916	H. Y. Walker	July 2, 1955

Consolidated Gold Fields in 1935 as assistant consulting metallurgist. Mr. Clemes was a member of the Institution of Mining and Metallurgy in England and a past president of the Chemical, Metallurgical, and Mining Society of South Africa.

John McNeil Forbes (Member 1933) of Montreal died June 6, 1955. He was president of Dubuisson Mines Ltd. and a noted consulting engineer. Mr. Forbes was born in Newfoundland in 1879 and received his B.Sc. from McGill University in 1906. He first worked with Canadian Allis-Chalmers Ltd. in the order dept. and then in the sales dept. From 1910 to 1912 Mr. Forbes was general manager, Black Lake Consolidated Asbestos Co. After exploration work in northern Quebec, Mr. Forbes was placed in charge of the Natural Resources Dept., Reid Newfoundland Co., and affiliated companies. Later he was at various times general manager, Siscoe Gold Mines Ltd., consulting engineer, Sullivan Gold Mines Ltd., and president, Beaufor Gold Mines Ltd. Aside from field work in Canada and the U. S., Mr. Forbes also carried out examinations in Uganda, Kenya, Tanganyika, and South Africa. He was a member of the Canadian Institute of Mining and Metallurgy.

J. W. R. Husen (Member 1953) died suddenly of polio in Marrakech, French Morocco, Mar. 23, 1955. Mr. Husen, representative of the Billiton Co. in Morocco, was born in Holland in 1916. After receiving his technical training from the Technische Hoogeschool in Delft, he was assistant to Prof. H. F. Grondijs in his economic geology and ore dressing laboratory. Mr. Husen was later chief engineer and then director of mines, Société Internationale d'Exploitation Minière au Maroc in Casablanca. He was also consulting mining engineer, Société Epermines in Casablanca, and more recently director, Société O.G.I.M. in Oued-Zem, French Morocco.

David Burnet Scott (Member 1949), for 18 years western sales manager, American Potash & Chemical Corp., Los Angeles, died of a heart attack June 20, 1955 at his home in Altadena, Calif. Mr. Scott was born in Slatington, Pa., in 1887 and was graduated from Williams College in 1908. After receiving his E.M. from Columbia School of Mines in 1911, he worked for Miami Copper Co., Miami, Ariz., until 1917. He was a construction and civil engineer, general mine efficiency engineer, and then assistant to the superintendent. Mr. Scott was later general manager, Socorro Mining & Milling Co., Mogollon, N. M., part-owner, Engineering Service Co., Los Angeles, and general manager, Natural Soda Products Co., Keeler, Calif. He was named head of the western sales office of American Potash & Chemical Corp. in 1934.

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Coming Events

Sept. 16, AIME Oregon Section, Burns Restaurant, Portland, Ore.

Sept. 24, AIME, Adirondack Section, Plattsburg Elks Club, New York. Speaker from General Electric Co. on labor relations.

Sept. 25-28, American Institute of Chemical Engineers, Lake Placid Club, Lake Placid, N. Y.

Sept. 26-30, Atomic Industrial Forum, trade fair, Sheraton-Park Hotel, Washington, D. C.

Sept. 28-Oct. 1, Southwest International Mining Assn. and New Mexico Mining Assn., joint meeting, El Paso, Texas.

Oct. 2-5, AIME MGGD fall meeting and Black Hills regional meeting of the Ind. Min. Div., Rapid City, S. D.

Oct. 6, AIME, Utah Uranium Subsection, 7:30 pm, Arches Cafe, Moab.

Oct. 6-8, AIME, Minerals Beneficiation Div., fall meeting, **Rocky Mountain Minerals Conference,** Salt Lake City.

Oct. 10-13, American Mining Congress, Metal Mining—Industrial Minerals Convention, Las Vegas, Nev.

Oct. 10-13, Fourth National Clay Conference, sponsored by the Clay Minerals Committee of the National Research Council, Pennsylvania State University, University Park, Pa.

Oct. 11, Illinois State Geological Survey, 50th anniversary, Natural Resources Bldg., University of Illinois Campus, Urbana.

Oct. 13-15, Annual Drilling Symposium, School of Mines and Metallurgy and the Center for Continuation Study, University of Minnesota, Minneapolis.

Oct. 14-15, National Society of Professional Engineers, fall meeting, Peabody Hotel, Memphis, Tenn.

Oct. 17-18, Conference on Mining Research, U. S. Bureau of Mines and Missouri School of Mines, Rolla, Mo.

Oct. 17-19, AIME-IMD, fall meeting, Adelphia Hotel, Philadelphia.

Oct. 17-21, National Safety Congress and Exposition, Conrad Hilton, Congress, Morrison, and La Salle Hotels, Chicago.

Oct. 19-20, ASME-AIME, fuels conference, Neil House, Columbus, Ohio.

Oct. 24-26, Sixth National Conference on Standards, sponsored by National Bureau of Standards and American Standards Assn., Sheraton-Park Hotel, Washington, D. C.

Oct. 27-29, AIME, Industrial Minerals Div., fall meeting, Hotel Charlotte, Charlotte, N. C.

Oct. 28, Illinois Mining Institute, 63rd annual meeting, Hotel Abraham Lincoln, Springfield, Ill.

Nov. 4, AIME-NOHC, Pittsburgh Local Sections, off-the-record meeting, Pittsburgh.

Nov. 11-12, AIME, Central Appalachian Section, annual fall meeting, Greenbrier Hotel, White Sulphur Springs, W. Va.

Nov. 13-18, American Society of Mechanical Engineers, Diamond Jubilee annual meeting, Congress, Hilton, and Blackstone Hotels, Chicago.

Nov. 15, AIME, National Open Hearth Steel Committee, Buffalo Section, 6th annual meeting, Royal Connaught Hotel, Hamilton, Ont.

Dec. 10-16, Atomic Exposition, Public Auditorium, Cleveland. Sponsored by the American Institute of Chemical Engineers in conjunction with the Joint Nuclear Congress.

Feb. 20-23, 1956, AIME, Annual Meeting, Statler and New Yorker Hotels, New York.

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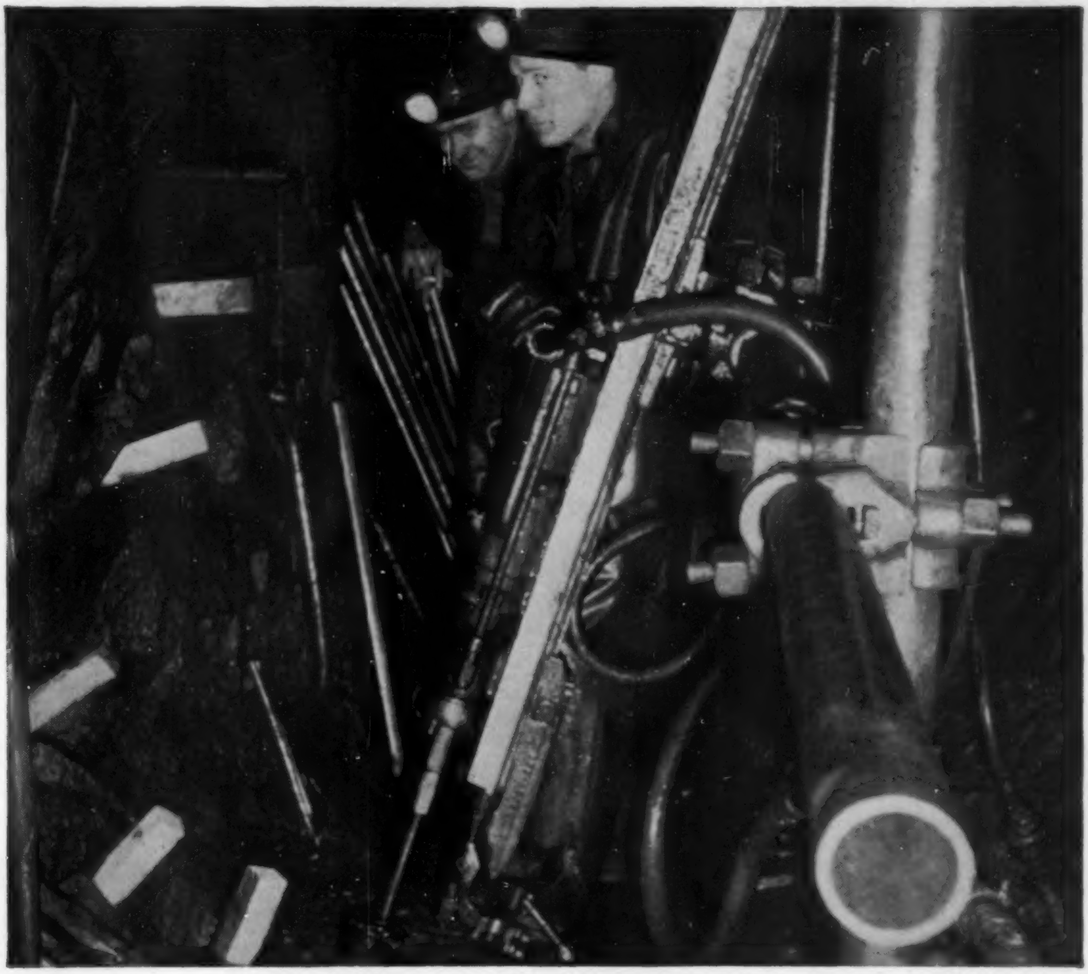

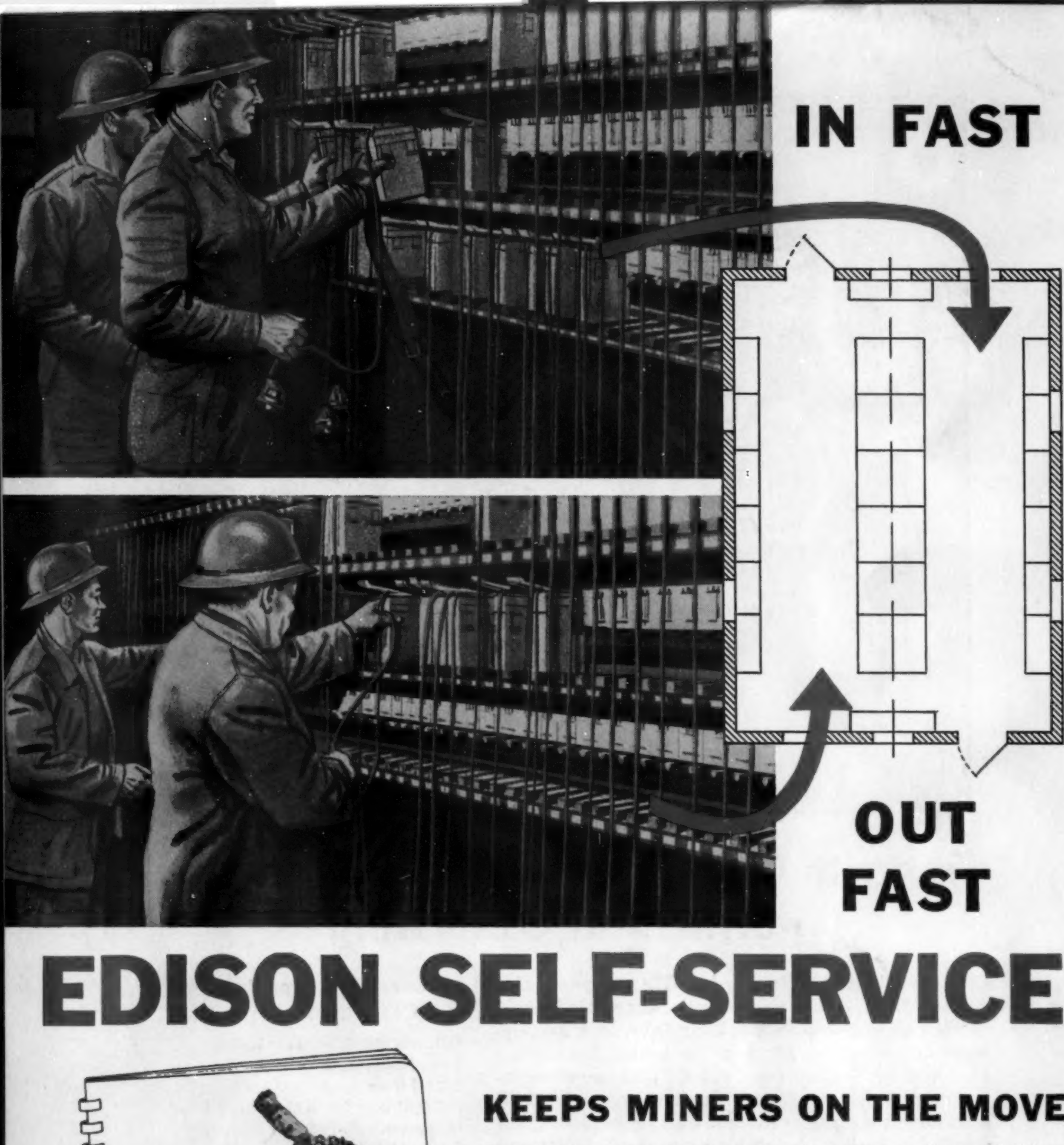

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